# CHAPTER 3 THE CASE STUDY

This chapter describes the scope and results of the case study that was carried out on a selected section of the East-West Highway. The objective of the case study was to collect the data and information needed to establish the road slope disaster management system including the Slope Information Management System (SIMS). It consisted of eight sections as shown below:

3.1 Outline of Case Study
3.2 Concept of Slope Disaster Management
3.3 Slope Inspection
3.4 Geological Investigation
3.5 Instrumentation and Monitoring
3.6 Preliminary Design of Countermeasure
3.7 Slope Disaster Management
3.8 Other Field Study

The main points of each section are summarised as below:

## 3.1 Outline of the Case Study

(1) The Role of the 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.

(2) The Scope of the Case Study

The Scope of the Case Study is summarised in Table 3.1.1.

Table 3.1.1 Scope of the Case Study

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

## 3.2 Concept of Slope Disaster Management

### (1) Flow of Road Slope Disaster Management

Figure 3.2.1 shows the flow of road slope disaster management planning. The procedures of road slope disaster management can be divided into three steps as shown in Table 3.2.1. The most important process in the slope management is: Slope Inspection, Risk Rating and Prioritisation of Implementation.

Table 3.2.1 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 |

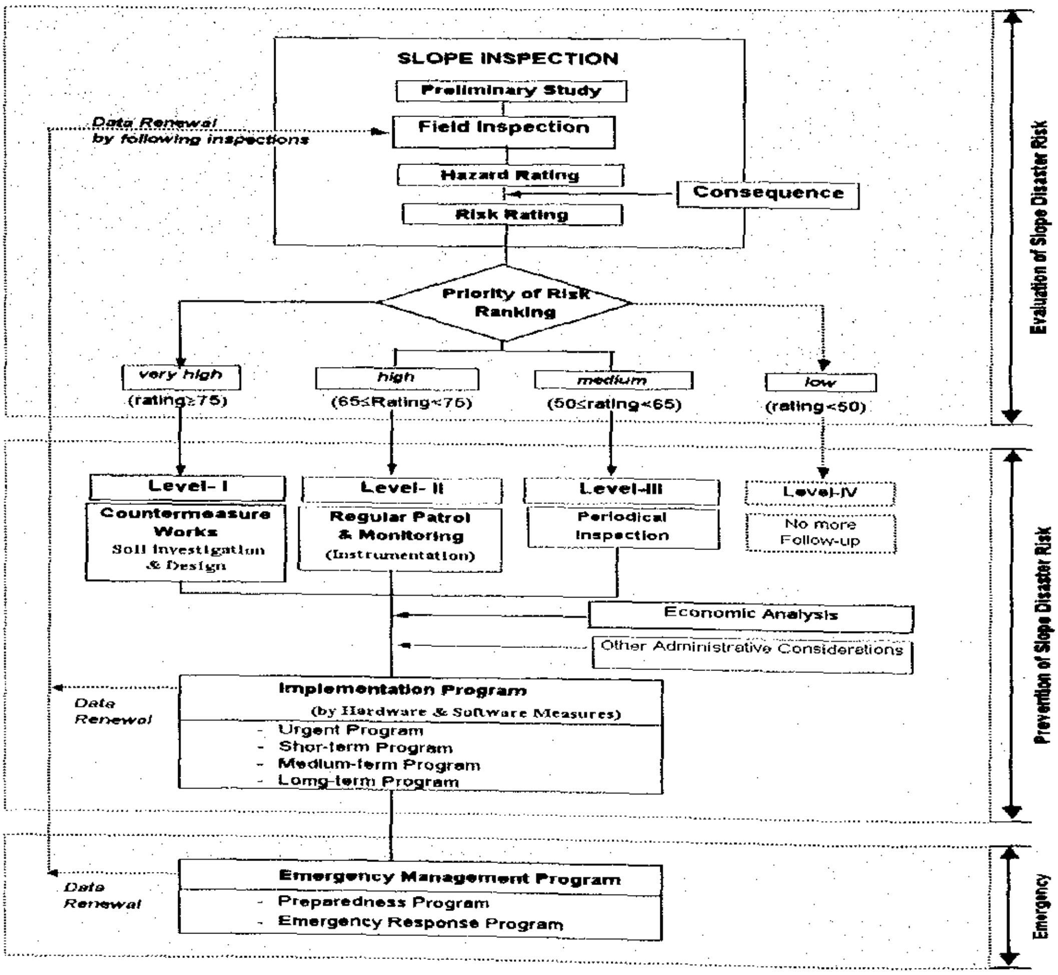



Figure 3.2.1 Flow of Road Slope Disaster Management

## 3.3 Slope Inspection

### 3.3.1 Outline of Slope Inspection

Slope inspection was carried out along the case study route to evaluate the risk of each slope against slope failure. 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.

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 methodology of slope inspection was in accordance with specifications established by the JICA study team, which are described in detail in Guide IIof the set of guidelines prepared in this study.

After the preliminary study of aerial photograph observation and reconnaissance survey, screening and classification of slope failure type was carried out. Geologists of a local private consulting firm, carried out actual slope inspection after first receiving technical training and guidance in the rationale and use of the system.

Observation, recording and rating of slopes was carried out in accordance with the inspection criteria for each of the six (6) slope failure types established by the JICA study team.

### 3.3.2 Hazard Rating and Risk Rating

(1) Criteria of Rating

The risk assessment for slope failure incorporates three aspects as below:

1) Assessment of slope stability conditions in respect of topography, geology, gradient, height and deformation of slope, which is called the "Score of Slope Stability".
2) Assessment of the effect of the existing countermeasure work, which is called the "Countermeasure Score".
3) Assessment of the expected effect of the disaster, should it occur, which is called the "Consequence Attributes Score".

The final risk evaluation is determined by combination of these three scores. The relationship between these scores and final risk rating is shown in Figure 3.3.1.

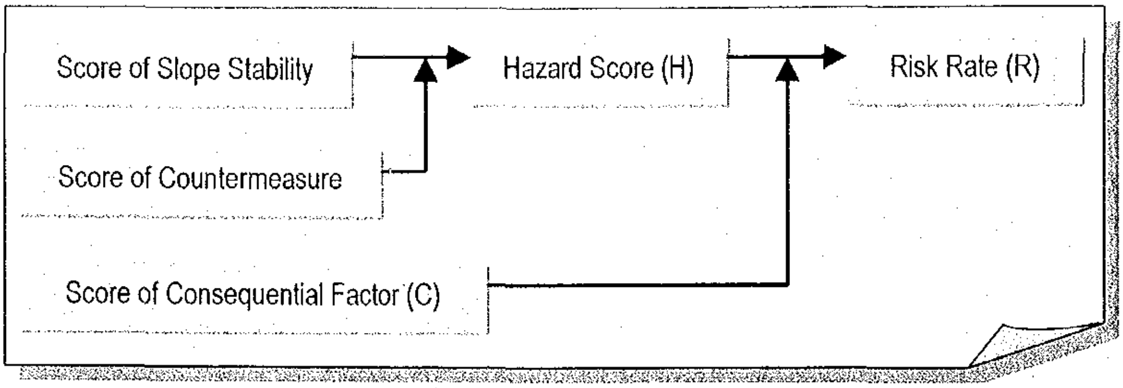



Figure 3.3.1 Determination of Stability Evaluation Score

Risk Rate is determined by the following formula.

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

Where,

Maximum mark of (H) and (R) is 100, while that of (C) is 10.

(2) Hazard Score

The weighting for each evaluation factor was determined through careful study of the criteria adopted in the current slope management systems in Malaysia and Japan. Items for evaluation of slope stability, and maximum slope hazard attribute points are summarised in Table 3.3.1 and Table 3.3.2, respectively.

Table 3.3.1 Items for Evaluation of Slope Instability

| Item | Cut and Natural Slope | Debris flow | Embankment Slope |
|---|---|---|---|
| Topography, Geometry, Geological structure | X | | |
| Geological condition, Deformation of slope, Surface conditions | X | | X |
| Culvert Conditions, Filling Material Scoring of River | | | X |
| Conditions of Upstream Slopes | | X | X |
| Catchment Area, Riverbed Gradient | | X | |

Table 3.3.2 Maximum Slope Hazard Attribute Points

| Items | Collapse/ Rock Fall | Rock Mass Failure | Landslide | Debris Flow | Embankment Failure |
|---|---|---|---|---|---|
| Topography | 5 | 11 | 50 | 43 | 0 |
| Geometry | 30 | 14 | 0 | 0 | 10 |
| Geological Structure | 14 | 33 | 10 | 0 | 0 |
| Geological Condition | 16 | 31 | 3 | 0 | 5 |
| Deformation | 15 | 7 | 32 | 34 | 26 |
| Surface Condition | 20 | 4 | 5 | 23 | 51 |
| Others | 0 | 0 | 0 | 0 | 8 |
| Total | 100 | 100 | 100 | 100 | 100 |

(3) Consequential Factor

The consequential score for estimating effects on the socio-economic environment was defined in accordance with the ones employed in SPRS and SMS system, with minor modification. The items for evaluation are as follows.

1) Danger to building occupants
2) Angle $\beta$ : road at centre line to crest or embankment toe
3) Failure size (volume)
4) Construction period of temporary diversion
5) Volume of traffic (annual average daily traffic)
6) Length of Alternative Road

Notes: Later during the review of SIMS, addition of one more item, "existence of service and public utility" was proposed by JKR, to be adopted in the revised version of the inspection sheets.

### 3.3.3 Proposed Countermeasure and Cost Estimation

Appropriate countermeasures were studied and proposed by the geologist/engineer involved in slope inspection. The countermeasure was selected in accordance with the likely type of slope failure in reference to the Guide prepared by the JICA study team.

Approximate cost for the proposed countermeasure was calculated using the SIMS based on the proposed scope of work and standard rate prepared by JICA study team. The purpose of the cost estimation is not for the detailed design but to support the implementation planning and budgeting at JKR headquarters.

Table 3.3.3 shows the countermeasure options by slope failure type, attached with typical rates.

Table 3.3.3 Countermeasure Options by Slope Failure Type with Typical Rates

| 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 ф 75mm perforated PVC pipe wrapped with a layer of Geotextile filter fabric of 3.0m into rock slopes | nos. | 450.00 |
| | 33b | Horizontal Drain Hole | Supply, drill & install ф 50mm perforated PVC pipe wrapped with a layer of Geotextile filter fabric of 9.0m length including construct drain outlet to existing berm drain | nos. | 600.00 |
| | 34 | Drainage Well | (To be estimated each case) | -- | -- |
| | 35 | Drainage Tunnel | (To be estimated each case) | -- | -- |
| 4 Slope work | 41a | Shotcrete (Mortar) | Minimum 75mm thickness shotcrete facing c/w one layer welded steel mesh ; supply BRC, ф 50mm PVC pipe with geotextile | $m^2$ | 100.00 |
| | 41b | Shotcrete (Mortar) | Minimum 125mm thickness shotcrete facing c/w two layers welded steel mesh | $m^2$ | 150.00 |
| | 42 | Shotcrete (Concrete) | -- | $m^2$ | 300.00 |
| | 43 | Cribwork (Precast) | -- | $m^2$ | 200.00 |
| | 44 | Stone Pitching | -- | $m^2$ | 500.00 |
| 5 Anchoring | 51a | Soil Nailing | 60 kN working load with minimum required length of 6 m inclusive of 0.5 m fixed length into rock | nos. | 600.00 |
| | 51b | Soil Nailing | --ditto—with minimum required length of 9m | nos. | 850.00 |
| | 51c | Soil Nailing | --ditto—with minimum required length of 12m | nos. | 1,200.00 |
| | 51d | Soil Nailing | --ditto—with minimum required length of 12m in soil | nos. | 1,000.00 |
| | 52 | Rock Bolt | 200 kN working load with minimum required length of 4.0 m | nos. | 1,500.00 |
| | 53 | Ground Anchor | Design & construct post-tensioned trial permanent ground anchors ; 300 kN working load | nos. | 5,000.00 |
| 6 Wall | 61a | Gabion Wall | Galvanized (For dry application) | $m^3$ | 45.00 |
| | 61b | Gabion Wall | PVC coated (For wet condition) | $m^3$ | 65.00 |
| | 62 | Stone Pitching | -- | $m^3$ | 70.00 |
| | 63 | Concrete Block Wall | Precast concrete block | $m^3$ | 280.00 |
| | 64 | Retaining Wall (Supported Type) | Concrete + reinforcement | m | 400.00 |
| | 65a | Crib Wall (Precast) | Single header (4.5 m – 5.0 m) | m | 210.00 |
| | 65b | Crib Wall (Precast) | Double header (5.0 m – 8.0 m) | m | 300.00 |
| | 65c | Crib Wall (Precast) | Triple header (8.0 m – 12.0 m) | m | 500.00 |
| | 66 | Pile Wall (PC / RC) | Spun pile ф 800 mm : Supply + install | m | 260.00 |
| | 67 | Pile Wall (PC/RC) | RC pile (400 x 400) : Supply + install | m | 110.00 |
| | 68a | Pile Wall (in-place) | Bored pile ф 600 mm : Concrete + Reinforcement + Link + Boring | m | 170.00 |
| | 68b | Pile Wall (in-place) | Bored pile ф 750 mm : Concrete + Reinforcement + Link + Boring | m | 250.00 |
| | 68c | Pile Wall (in-place) | Bored pile ф 900 mm : Concrete + Reinforcement + Link + Boring | m | 350.00 |
| | 68d | Pile Wall (in-place) | Bored pile ф 1,050mm: Concrete + Reinforcement + Link + Boring | m | 450.00 |
| | 69a | Pile Wall (Steel Sheet Pile) | Supply & deliver to site Type FSP IIIA steel sheet pile | kg | 2.10 |
| | 69b | Pile Wall (Steel Sheet Pile) | Handle, pitch and drive steel sheet pile | nos. | 100.00 |
| 7 Pilling | 71 | Steel Pipe Pile | Steel pipe ф 400 mm | m | 2,000.00 |
| | 72 | H Steel Pile | H steel (400 x 400) -- | m | 2,000.00 |
| | 73 | Shaft Work for Resistance Slide | ( To be estimated each case) | -- | -- |
| 8 Protection Work | 81 | Rock Fall Catch Net | -- | $m^2$ | 100.00 |
| | 82 | Rock Fall Catch Fence | Supply & erect PVC coated chain link fence including concrete kerbs, posts, structs, staining wires, barbed wires etc. (Reservoir compound) | $m^2$ | 200.00 |
| | 83 | Rock Shed | -- | $m^3$ | 400.00 |
| | 84 | Debris Shed | -- | $m^3$ | 400.00 |
| | 85 | Slit Dam | -- | $m^3$ | 300.00 |
| | 86 | Check Dam (Sabo Dam) | -- | $m^3$ | 300.00 |
| 9 Others | 91 | Diversion (Shifting) | (Earth work and structure work should be estimated each case) | m | 300.00 |
| | 92 | Route Relocation | (To be estimated each case) | m | |

### 3.3.4 Result of Slope Inspection

(1) Number of Slopes Inspected

The results of slope inspection are shown in Figure 3.3.4. In the case 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). All data collected in the slope inspection were input into the SIMS.

(2) Hazard Rate

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.

Table 3.3.4 Summary of Slope Inspection Result

| Type of Slope Failure (Disaster) | Hazard Rate | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ≥85 | 84-80 | 79-75 | 74-70 | 69-65 | 64-60 | 59-55 | 54-50 | ≤49 | no point | |
| Collapse | 0 | 0 | 1 | 4(3) | 3 | 5 | 13 | 7 | 51 | | 84 |
| Rock Fall | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | | 4 |
| Collapse / Rock Fall | 0 | 1 | 3 | 1 | 4 | 6 | 10 | 6 | 71 | | 102 |
| Rock Mass Failure | 0 | 0 | 0 | 2 | 2 | 2 | 2 | 1 | 2 | | 11 |
| Landslide | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | | 6 |
| Debris Flow | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 6 | | 7 |
| Embankment | 0 | 0 | 1 | 0 | 4 | 2 | 9 | 14 | 230 | | 260 |
| Out of Inspection | | | | | | | | | | 296 | 296 |
| Total | 1 | 2 | 6 | 8(3) | 13 | 16 | 35 | 29 | 364 | 296 | 770 |

* ( ) : number of slopes that contained both Collapse and Landslide

## 3.4 Geological Investigation

Model of detailed study

Along the case study route, three sites were selected for detailed study, including geological investigation, instrumentation, monitoring and preliminary countermeasure design. These studies were carried out to collect the information to establish a slope information system and technical specifications for the guidelines of the slope management system.

Selection of the test site

Three slopes were selected along the EW 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

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.

Example of Investigation Result

Figure 3.4.1 and 3.4.2 show a seismic velocity profile and electrical resistivity profile, respectively, at CH 81.30 km.

Figure 3.4.3 shows a geological section at CH 81.30 km.

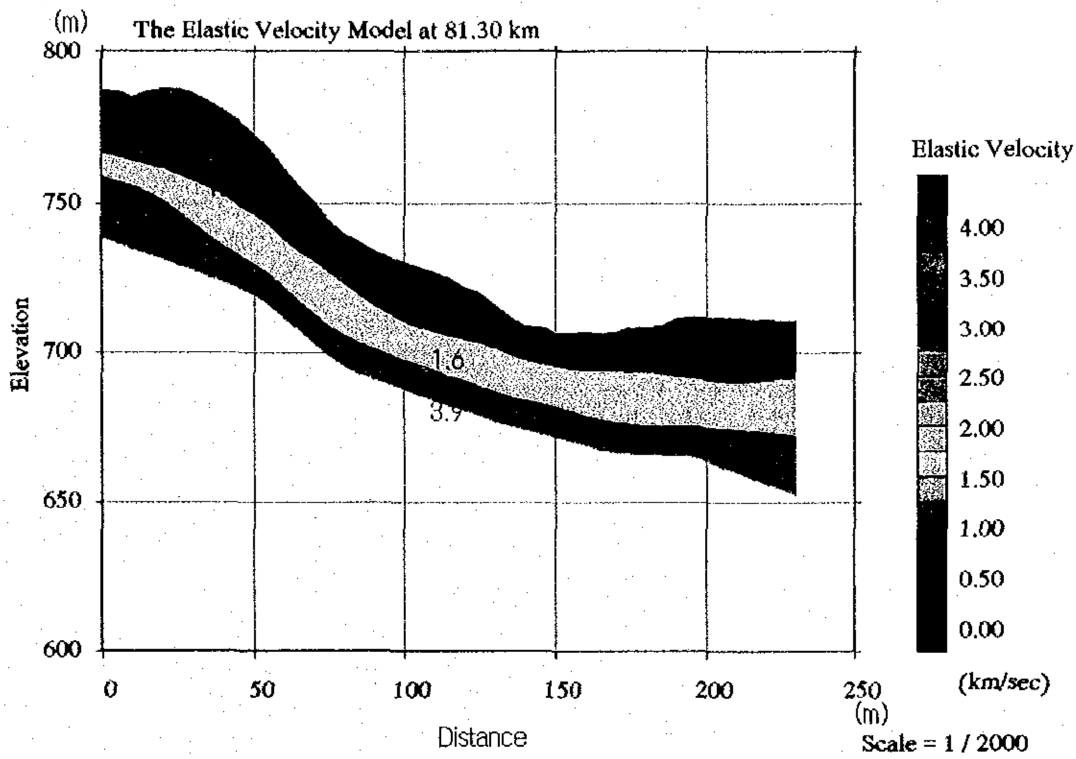



Figure 3.4.1 Elastic velocity model section C-C': 81.30 km

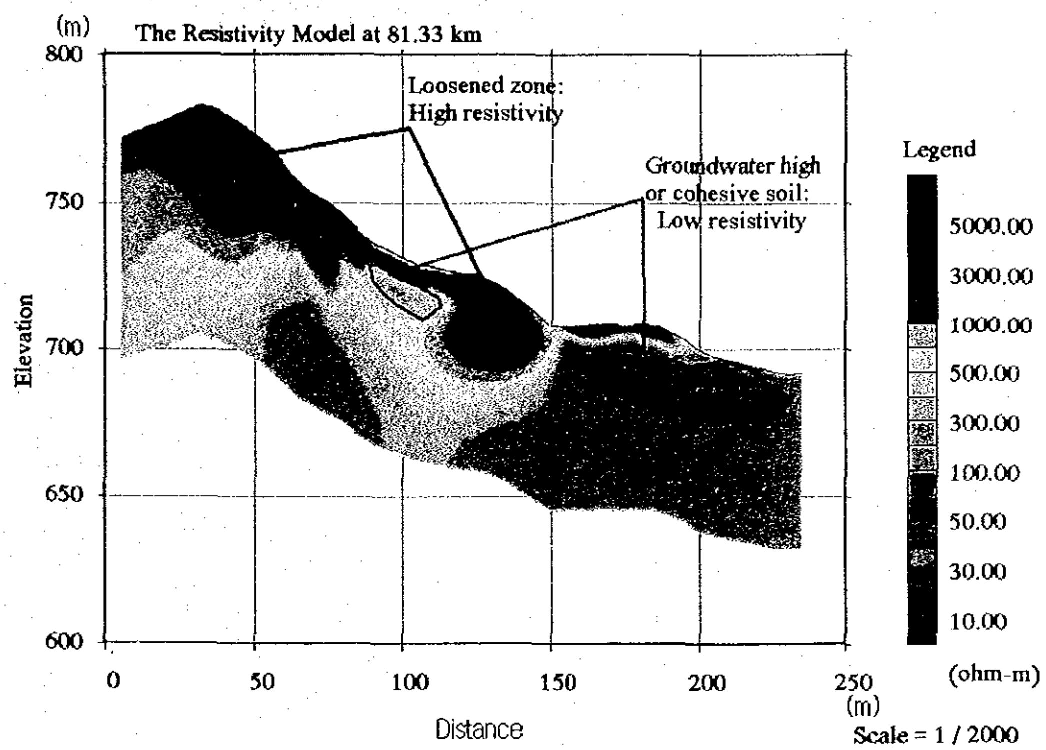



Figure 3.4.2 Resistivity imaging model section C-C': 81.30 km

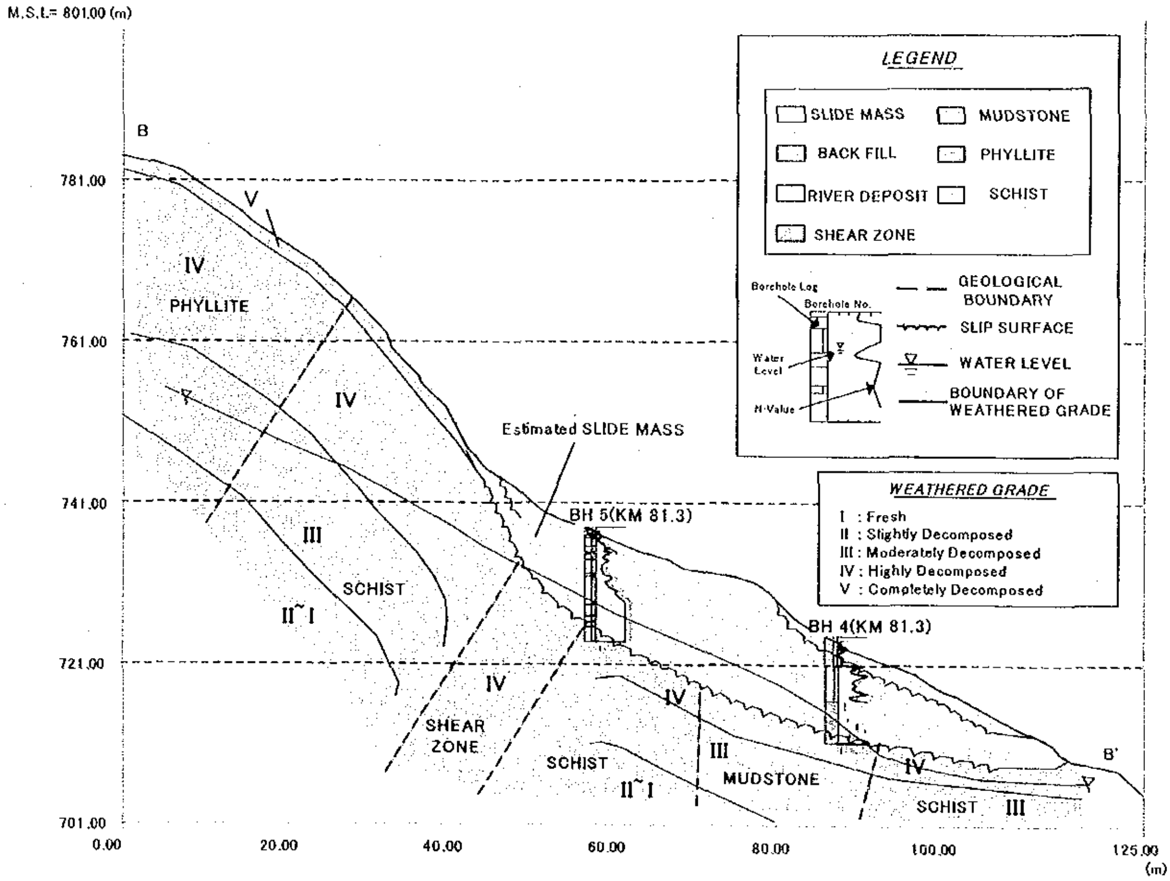



Figure 3.4.3 Geological Section at CH 81.28 km.

## 3.5 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.

Monitoring using instruments has two important roles:

1) During the investigation stage, monitoring data can give essential information on the design of countermeasures, regarding the area and depth of possible failure zones, the mechanism of failure, the rate of movement and the expected time range until failure and so on.
2) During the slope maintenance stage, monitoring data can give useful information to support the decision-making for traffic control, such as administrative traffic blockade, slower speed limit, alert notices, etc., based on accelerated landslide movement or heavy rainfall surpassing the pre-set criteria.

### 3.5.1 Installation of Instrumentation

Several kinds of instrument were installed as shown in Table 3.5.1.

Table 3.5.1 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 |
| Water Standpipe | 1 | 0 | 1 | |

### 3.5.2 Monitoring

Since the installation of each instrument, measurement has been automatically carried out (except for inclinometer, which has been measured manually at ten days interval). The measured data are stored in memory media within the instrument on site, and periodically collected for processing.

So far, each instrument has been working normally. The measurement record of each instrument is as below:

1) Regarding the extensometer and inclinometer, no evidence of ground movement has been observed.

2) Regarding piezometer and water standpipe, some fluctuation is observed with seasonal change or by influence of rainfall.

3) Regarding rain gauge, maximum rainfall intensity (hourly rainfall) during July to the beginning of November, 2001 was as below:

   Ch 27.0 km: 33.2 mm/hour (29 Oct. 2001)

   Ch 30.3 km: 34.4 mm/hour (24 Jul. 2001)

   Ch 81.3 km: 36.4 mm/hour (21 Jul.2001)

   It is noticed in the record that the rainfall pattern of each station is generally similar to one another, but on some occasions, a completely different tendency is observed between the data at Ch 27.0 km and those at Ch 30.3 km, with only 3.3 km separating the two gauges).

## 3.6 Preliminary Design of Countermeasure

Preliminary design of countermeasure was carried out as model study at three selected slopes representing typical type of failure; at CH 27.00 km for Collapse and Landslide, at CH 30.32 km for Embankment Failure, and at CH 81.30 km for Landslide.

### 3.6.1 CH 27.00 km (Collapse and Landslide)

This slope has risk of two types of failure, Collapse and Landslide. The countermeasure was designed primarily to work against landslide because landslide could cause larger damage to traffic. Slope stability analysis was carried out based on the geological investigation result. Study was made for two cases with different types of work.

Case I Counterweight embankment and road diversion

Case II Crib work and ground anchors

### 3.6.2 CH 30.4 km (Embankment Failure)

The embankment slope has a maximum height of 35 m. Embankment material is mainly silt with low content of sand and gravel. Most of the fill was compacted to a higher N-Value than 20. The estimated collapse pattern is a progressive failure from lower part to upper part. So, as an appropriate countermeasure at this slope, a complete drainage system was proposed at the berm and at the boundary of the original ground and embankment. The estimated quantity of work is, Drain ditch and cascade of 180 m, and Surface drainage of 330 m.

### 3.6.3 CH 81.3 km (Landslide)

There is a rock gabion wall with a length of 150 m in front of the slope. At the top of the slope, a scarp feature, characteristic of a landslide, is obvious. It was observed that the gabion wall has been lifted up at the centre of the landslide area.

According to the boring result, the base rock of the slope is composed of interstratified sandstone and schist, but well sheared. The results of seismic survey show that the highly to moderately weathered rock zone occurs 15 m to 20 m under the surface and highly to moderately weathered rock zone occurs 30 m to 40 m under the surface. The results of the resistivity survey show that high resistivity zones exist at the cut slope of the roadside and upper part of the scarp, but that a low resistivity zone exists in the middle part of the landslide. It is considered that this low resistivity zone is a high groundwater zone.

Appropriate countermeasure was studied by slope stability analysis based on the geological investigation results. Two types of countermeasure option were studied:

**Case I** Road relocation counterweight embankment, and horizontal drain holes

**Case II** Restraint works by steel pipe piles and horizontal drain holes (Steel Pipe Piles $\phi$ 400 mm, t24 mm, 2.0m pitch (H), L = 17.5 m, Total length 1,312.5 m)

### 3.6.4 Cost Estimate of Countermeasures (East-West Highway)

The estimated cost of each case study site is:

| | | | |
|---|---|---|---|
| (1) | CH 27.00 km (Collapse, Landslide) | | |
| | Case I | Road relocation and counterweight embankment | RM 347 k |
| | Case II | Ground anchor | RM 5,632 k |
| (2) | CH 30.40 km (Embankment failure) | | RM 18 k |
| (3) | CH 81.30 km (Landslide) | | |
| | Case I | Road relocation, counter embankment and drain hole | RM 305 k |
| | Case II | Restraint works by steel pipe piles and horizontal drain holes | RM 3,969 k |

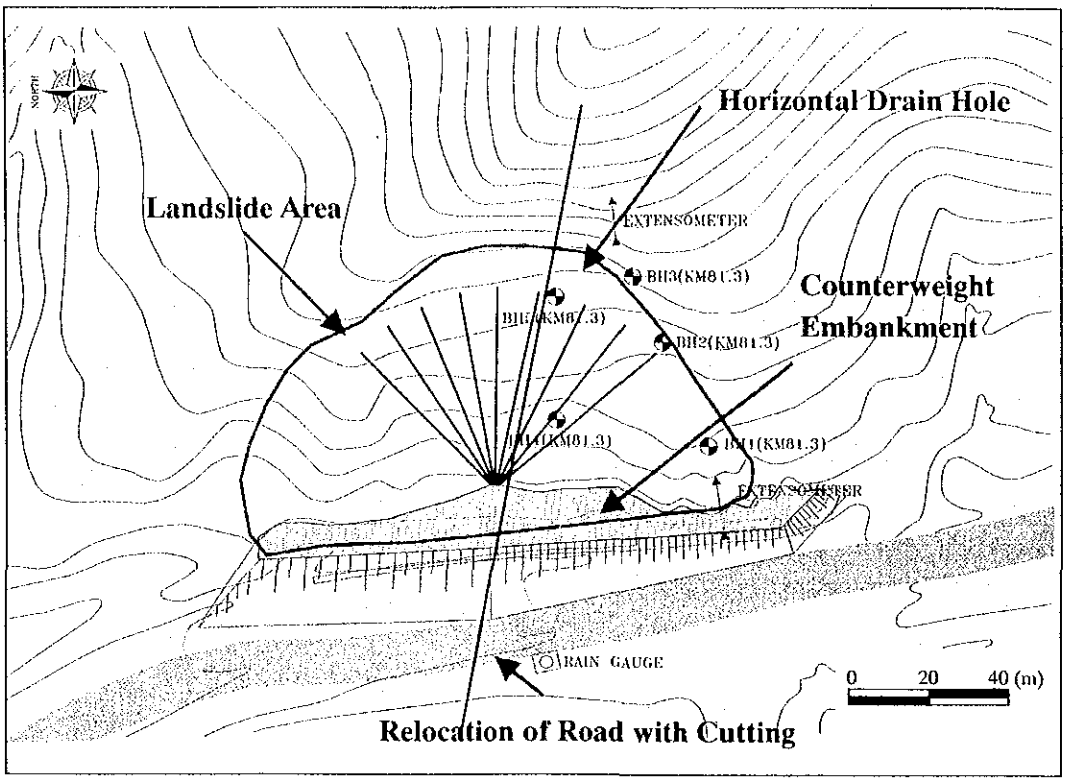



Figure 3.6.1 Plan of counterweight embankment at CH 81.30 km.

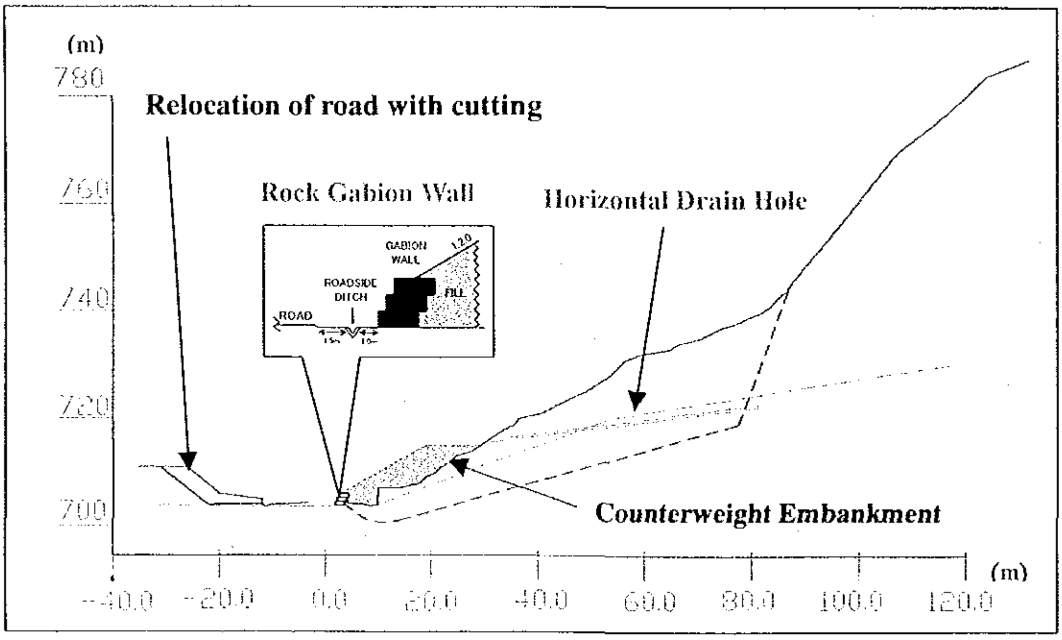



Figure 3.6.2 Cross section of counterweight embankment at CH 81.30 km.

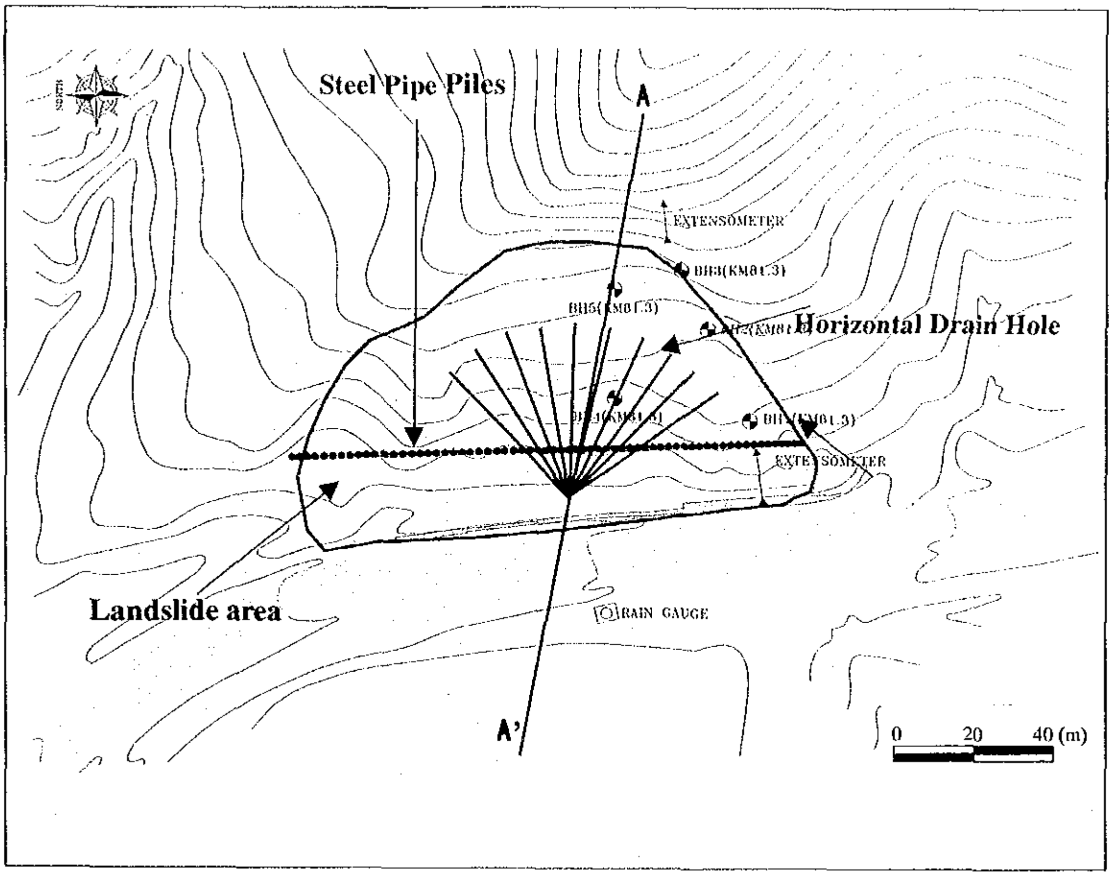



Figure 3.6.3 Plan of Steel-pipe pile works at CH 81.30 km.

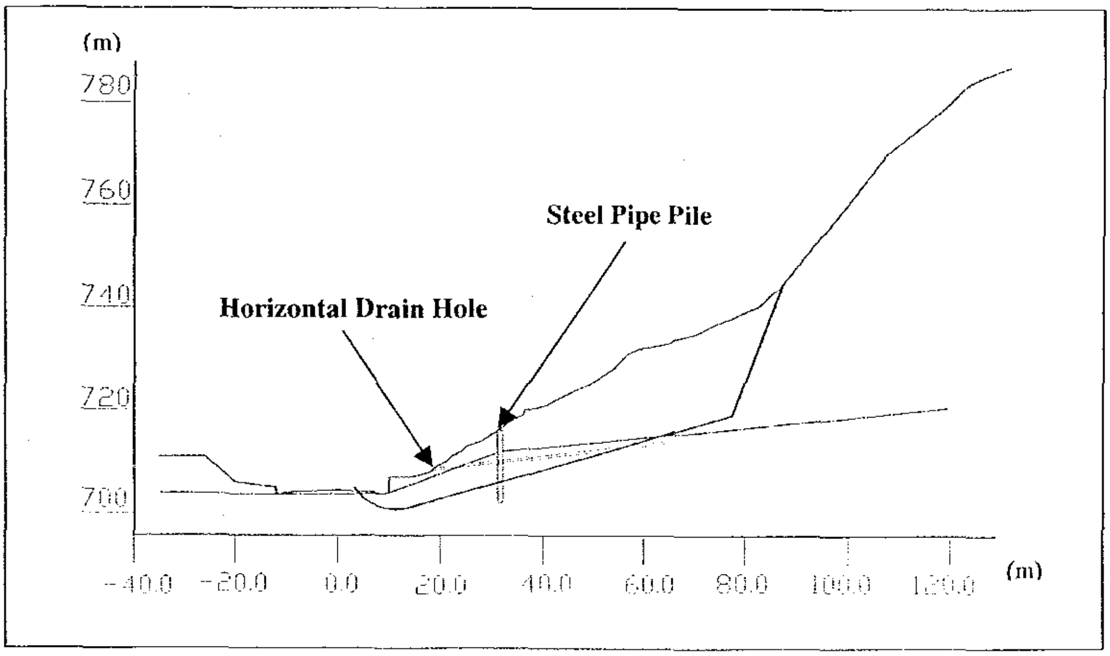



Figure 3.6.4 Cross section of Steel-pipe pile works at CH 81.30 km.

### 3.6.5 Preliminary Design of Countermeasure of Penanpang-Tambunan Road

Additional study was carried out in Sabah State for the purpose of checking the system of slope inspection, rating and preliminary countermeasure design. Two slopes were selected for the study; Slope No. S05 (landslide) and S19 (rock fall).

(1) S05 Slope

Slope disaster was found by subsidence of the road with breakage of the pavement. The subsidence has recently reached more than 2 m. It is assumed that the slope is originally in a landslide area and that the additional load of the road embankment has accelerated the movement of the landslide, together with the effect of upheaval of groundwater level. Appropriate countermeasures were studied for the four cases:

Case I: Counterweight embankment and Horizontal drain holes.
Case II: Counterweight embankment and Drainage well.
Case III: Horizontal drain holes and Steel pipe piles
Case VI: Drainage well and Steel pipe piles

(2) S19 Slope

Collapse is occurred in a mountainside slope. The upper part of the slope consists of unstable residual soil, boulders and highly weathered rock. The middle and lower parts of the slope consist of boulders and soft soil that have fallen from the slope above. The roadside drain is buried and broken by fallen rocks. Boulders and soils in the slope are unstable

**Case I:** Road shifting and catch gabion wall
**Case II:** Ground anchor with crib

### 3.6.6 Cost Estimate of Countermeasures (Sabah)

The estimated cost of the each case study site is as follows;

(1) S 05 Slope (Landslide)

| | | Cost (RM) |
|---|---|---|
| Case I | Horizontal drain holes and Counterweight embankment | 324,000 |
| Case II | Drainage well and Counterweight embankment | 687,000 |
| Case III | Horizontal drain holes and Steel pipe piles | 2,550,000 |
| Case VI | Drainage well and Steel pipe piles | 2,619,000 |

(2) S 19 Slope (Rock fall)

| | | Cost (RM) |
|---|---|---|
| Case I | Road shifting and catch gabion wall | 2,619,000 |
| Case II | Ground anchor with crib | 2,619,000 |

## 3.7 Slope Disaster Management

(1) Categorisation based on the Slope Risk Rating

Table 3.7.1 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 3.7.1 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

Priority Risk Ranking List

Table 3.7.2 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 3.7.2 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 | | |

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. Table 3.7.3 shows a suggested concept of prioritisation, taking into account both engineering factors and the importance of the road. The former factor can be represented by Hazard Rating (H), while the latter can be the consequence score, result of economic analysis and other administrative requirements.

Table 3.7.3 Concept of Priority in Countermeasure Implementation

| Hazard Rating Score (H) / Importance of Road | | Very High | High | Moderate | Low |
|---|---|---|---|---|---|
| | | H≥ 75 | 65≤H<75 | 50≤H<65 | H<50 |
| Highly important road | Likely large impacts on industrial/ social activities | A | B | D | |
| Moderately important road | Likely moderate impacts on industrial/ social activities | B | C | | |
| Less important road | Likely minor impacts on industrial/ social activities | D | | | |
| Notes: | 1) Priority in Implementation should be in the order of A-->--> B--> C<br>2) Zone 'D' will not require preventive program, except for emergency.<br>3) Importance of road can be determined by consequence, economic analyais, and other administrative requirement. | | | | |

Definition of Importance of Road

Table 3.7.4 summarises various kinds of indicators that may influence the potential for damage of a slope disaster. In another words these can be used to measure the importance of the road/slope for disaster management. It is recommended, for the time being, to use the traffic volume as a simple and practical indicator for evaluation of the importance of the road in prioritisation, although further study should be continued by JKR to establish practical criteria for decision-making.

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 3.7.5 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 3.7.4 Major Indicators of Importance in Management of Road Slope

| | Consequence (SIMS) | Economic Analysis (under study) | Additional consideration |
|---|---|---|---|
| Evaluation of relevant Road condition | Traffic volume<br>Alternative road<br>Service & Public Utilities | Traffic volume<br>Population<br>Industrial and agro products | Other industrial activities (tourism etc.)<br>Future Development Plan<br>Local community requirements<br>Administrative requirements |
| Evaluation of relevant Slope condition | Nearby Residential houses<br>Geometry (slope crest/toe)<br>By-pass availability<br>Possible failure size | Countermeasure cost | |

Table 3.7.5 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

Priority in Implementation in Case Study

For the case study route, nine (9) slopes were identified as Very High risk. (Please refer to Table 3.7.1). 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).

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. (Naturally even Very High-risk slopes should be carefully monitored until the completion of countermeasures.) The details of the slope maintenance program are described in Guide I, whilst some of the main points for slope maintenance are show below.

Table 3.7.6 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: Moderate-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.

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.

Traffic Control under Heavy Rain Condition

According to experiences, most large-scale slope failure is apt to occur during or just after heavy rain. This is the basis of traffic control in the use of rainfall data. To establish reliable rainfall criteria (or thresholds), it is necessary to accumulate and analyse actual historical rainfall data of each district in connection with rainfall 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.

## 3.8 Other Field Work

### 3.8.1 Aerial Photograph and Mapping

The purpose of this work was to prepare base maps for SIMS to be used in slope disaster management. The work consisted of aerial photography, orthophoto mapping, photogrammetric mapping, topographic mapping, cross-section and ground control survey. The area surveyed is along the East West Highway (from CH 23.1 km to 84.3 km) with 61.2 km long and 2 km wide. Aerial photographs were taken under clear sky conditions during the month of February 2001.

### 3.8.2 Environmental Consideration

Environmental Impact Assessment (EIA) is required under regulations to be carried out for the construction of new roads. However, there are no regulations related to the environmental impacts of maintenance of existing roads.

The main environmental problems, which may arise through operation and maintenance of roads, are the inflow of turbid water into streams by heavy rain and destruction of vegetation by slope failure. Particularly, the inflow of turbid water has to be considered for its environmental impact, as it may affect a large part of the downstream area.

Along the East-West Highway, most slopes have been vegetated artificially by spraying grass seeds. However, some of the mountain and valley slopes were found to be bare due to slope failure. Those uncovered slopes should be treated as soon as possible, as it may be the source of another slope failure or turbid water flow.

# CHAPTER 4 DEVELOPMENT OF SLOPE INFORMATION MANAGEMENT SYSTEM (SIMS)

This chapter consists of nine sections as below:



A summary of each section follows.

## 4.1 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.

At the outset of this project, the design concept of SIMS was clearly articulated as:

- Application Appearance
    - o Simple to use application functional on a PC with Microsoft Windows Operating System
    - o A menu-based simple application workflow with guidance for data entry through drop-down lists and defined choice options where possible.
    - o Provide standard/ default settings for ease of use/ uniform use
    - o Provide customisation possibility for experienced user
- Application Deployment
    - o Applicable and useable all over Malaysia through a common set of standard information and procedures incorporated into the application
    - o Main installation at JKR Headquarters in Kuala Lumpur with information for all of Malaysia.
    - o Provide for a multiple-seat installation at headquarters, using a centralized database, and stand-alone installation functionality for remote/district offices
    - o Similar installation of applications for district/ local offices to collect and use regional information in coordination with headquarters
    - o An appropriate mechanism for data exchange must be developed to ensure that data from district offices could be integrated together in a master-

database at the Headquarters, and so that updated information from Headquarters could be fed back to the districts.

- Application Technology
  - o A relational database environment to be used to manage all slope information, recognizing that this application will have to address slope information for all of Malaysia.
  - o GIS functionality was required in the overall design of the proposed system
- Application Functionality
  - o Desired application functionality was to be clearly defined through iterative guidance from the JICA Study Team and JKR.
  - o Clearly evident functionality through simply organized menu structure
  - o General user of the application should not require knowledge of database technology
  - o GIS functionality should be presented simply to ensure that the general user will not be required to have detailed knowledge of GIS to use the application

The design guidelines were formally presented at a seminar held on 22 May, 2001, in the interim report at the 4th Steering Committee meeting on June 7th, 2001, and the application developed based on these guidelines was demonstrated during the Workshop held on September 26th, 2001.

Discussions were also held with key persons within JKR, at the main office and at the local offices responsible for the East-West Highway, to understand the needs of the Road Maintenance Unit and to define their expectations of a software application developed for their use.

Based on the discussions with JKR staff, the functionality expected from the proposed application was conceived as being suited to facilitate:

- Slope Inspection and Maintenance (currently available in SMS)
- Slope Hazard and Risk Ratings (currently available in SPRS)
- Countermeasure Selection
- Cost Estimation of Countermeasures
- Facilitate Economic Analysis for Prioritization of Countermeasure Implementation
- Create maps of slope features to best represent analyses

## 4.2 Program Design and Development

For the development of SIMS, two different concepts were explored; Option I (Networked/ Stand-alone Application Environment, Not Internet Dependent) and Option II (Web-

Integrated Environment for Application Deployment). The limitations and benefits of both options were presented and discussed with JKR.

Based on our assessment of the limitations of infrastructure, resources available within JKR, limited connectivity to JKR offices outside Kuala Lumpur, and the limited time period for actual development and testing of the application, it was agreed by the JICA Study Team and JKR that the application be developed along the lines as outlined in Option I, without internet dependence. The application structure was conceived as having a custom developed software program that would encompass the intellectual framework for each of the modules established by the JICA Study Team. Through this custom developed software, the functionalities of database software and GIS software would be leveraged for the user, eliminating the need for them to have technical knowledge of either technology.

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 4.2.1 and Table 4.2.1.

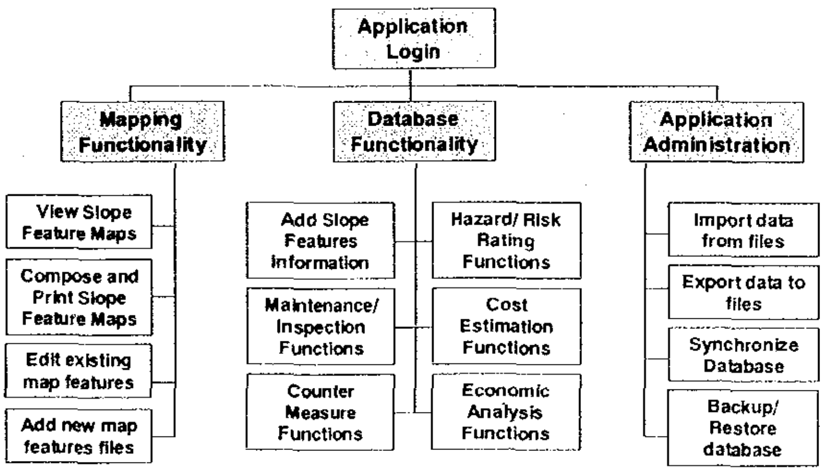



Figure 4.2.1 Summarized Application Functionality

Table 4.2.1 Application Functionality of SIMS

| | *Modular Functionality of Proposed Software* | *Guidance Sources* | *Notes/ Comments* |
|---|---|---|---|
| 1. | Slope Inspection | SMS | Use forms similar to those from Field Inspection Methodology |
| 2. | Hazard/Risk Rating | SPRS/ JICA Team | While the currently in-use SPRS logic will be reviewed carefully, this rating system will be based on the Field Inspection Methodology developed by the JICA team |
| 3. | Countermeasure Design and Cost Estimation | JICA Team/ SPRS | The functional logic to be designed with assistance of the geo-technical experts in the JICA Team. The costing function addresses a similar functionality provided in SPRS |
| 4. | Economic Analysis | JICA Team | Based on easily accessible information, an Economic Analysis ratio is used to comparatively evaluate the Slope Features. |
| 5. | GIS Functionality | JICA Team | Review of Slope Features based key attributes such as slope type, risk rating, countermeasure cost, etc. |
| 6. | Administrative Functions | | Database Maintenance/ User Permissions/ Version Control. |

The data to be used in SIMS can be readily categorized into:

- Slope Feature Information that is text-based (alpha-numeric) and archived in the SIMS Database
- Slope Feature Graphics (slope inspection sketches and photographs) residing on a computer system, preferably the same as that of the database
- GIS related data (slope polygons defining the spatial extent of the slope feature, other geographical information) also residing on a computer system, preferably the same as the system with the database

Through successive presentation of the development of the application (in the seminar on 26th September, 2001), and through formal and informal discussions, training sessions, and reviews with the JKR and the JICA Study Team, the application design was refined and changes made.

Based on guidance received, the application menu structure was finalized as main modules consisting of Slope Information, Hazard/Risk, Countermeasure, and Economic Analysis modules, an Integrated Reporting module, to provide an easily identifiable functionality in the application to help the user generate reports based on any of the main modules, and a GIS module incorporating the mapping and analysis functionality as a distinctively separate module, and.

## 4.3 Managing Slope Disaster Using SIMS

Designed to coincide with the Slope Inspection Forms developed by the geotechnical experts in the JICA Study Team, 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. Details of the reporting and mapping functionality are described further in this report.

## 4.4 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.

## 4.5 Proposed Deployment Plan of SIMS

Working with the goal of using SIMS at a nation-wide level, its successful deployment at the JKR headquarters and at the district/zonal locations identified is dependent on institutional ownership and support, training of SIMS users, and its effective integration with the Slope Inspection and maintenance procedures.

For the successful deployment of SIMS, it is also essential to have IT and GIS support. Through participation of experienced IT persons, problems arising out of changes in computing technology, operating systems, and the computing infrastructure can be more effectively addressed and proactively managed.

The continued involvement and guidance of focal GIS resources from within JKR are essential to guide the Road Maintenance Unit on issues arising out of GIS technology options and changes, creation and management of GIS data, and integration of GIS activities in the Road Maintenance Unit with other institutional/organizational use of GIS.

Different levels of users are anticipated to be trained for the effective deployment of SIMS. For most day-to-day operation, the users will be given training in all modules of SIMS, except for those addressed by administrative resource persons. An understanding of the purpose and type of administrative functions included in the application will be communicated to all users, making them aware of the kind of instances where they would require administrative support.

A more advanced level of training will be imparted to the administrative users to sensitise them regarding the importance of the administrative functions in the application, as well as to make them familiar with the nature of administrative functions to be addressed. These administrative persons should include a key resource from JKR HQ, who will also serve as the point-of-contact for all the users at headquarters and at stand-alone installations, ensuring that the data exchange keeps all databases up to date and synchronized.

# CHAPTER 5 APPLICATION OF SLOPE INFORMATION MANAGEMENT SYSTEM (SIMS)

This chapter consists of five sections as below:

5.1 Application of SIMS to Case Study Route
5.2 Application of SIMS to Penampang-Tambunan Road, Sabah
5.3 Economic Analysis
5.4 Future Deployment of SIMS

## 5.1 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 risk ratings have been computed by SIMS. 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.

To make the GIS module functional, the slope feature polygons have been created in the data format required (ArcView shape files). These features were originally created using the slope ID's assigned in the field. With the revisions to the conventions for assigning SlopeID's, the work became very complicated. This process is expected to be simpler in future use of SIMS as a result of the better defined JKR Slope ID, and a closer correlation between the JKR Slope ID and the ID used by field people.

The lessons learnt from the use of SIMS in the case study have contributed to improving the application, better coordinating the Slope Inspection Forms with SIMS and vice-versa, and clearly defined processes for data entry, editing, and data creation. It has specifically contributed to a clearer definition of the process required for GIS data creation for the slope features.

## 5.2 Application to Penampang-Tambunan Road

### 5.2.1 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.

### 5.2.2 Selection of Slopes

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.

### 5.2.3 General Condition

The inspected slopes are located in a mountainous area about 1,400 m to 1,700 m above mean sea level. The road has been built by cut-and-fill along a ridge extending from north to south. The area is covered with mixed vegetation, mostly of primary forest or secondary jungle. Geologically, the bedrock is Tertiary Crocker formation, composed mainly of an alternation of sandstone and shale and striking NW-SE.

### 5.2.4 Results of Slope Inspection

Detailed results of the slope inspections were input to the SIMS and submitted as electronic file.

(1) Classification of Slope Failure

All of the slope failure types defined in this JICA study (except for rock mass failure) were found in the test section. The most common failure type was Collapse/Rock Fall, followed by landslide. The past remains of a debris flow were found in a stream. Surface erosion, shoulder cracks or small collapse were found in embankments.

(2) Risk Rating

The Risk Rating for each slope was calculated from "Hazard Score" and "Consequence Score" in use of SIMS. Four slopes were rated as very high (>75); three of them are subject to Collapse/Rock Fall, while one slope is subject to Landslide.

Table 5.2.1 Risk Rating by Type of Slope Failure

| Type of Disaster | Number of Slopes | Risk Rating |
|---|---|---|
| Collapse/Rock Fall | 13 | 43 - 84 |
| Rock Mass Failure | 0 | - |
| Landslide | 7 | 60-83 |
| Debris Flow | 2 | 73 |
| Embankment Failure | 1 | 25 |

Table 5.2.2 : Priority Category with Risk Rating Score

| Priority Category | Range of Risk Rating Score | Number of Slope in the Area |
|---|---|---|
| Very High | H≥75 | 4 |
| High | 65≤H<75 | 11 |
| Moderate | 50≤H<65 | 6 |
| Low | H<50 | 2 |

(3) Countermeasure

Appropriate countermeasures were proposed for each slope in accordance with the Guide established in this JICA study. The total estimated cost for 22 slopes, i.e. excluding S05 (Landslide), is RM1,800,000.

### 5.2.5 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.

## 5.3 Consideration of Economic Analysis

### 5.3.1 Economic Indicator in SIMS

The Study Team has made much effort to introduce the economic analysis into the SIMS. But 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.

In these situations, thinking of importance of economic analysis to evaluate the feasibility of the road disaster prevention work, a simpler economic indicator was studied and applied to the SIMS as below, while the basic concept, methodology and result of the economic analysis are presented in 5.3.2 – 5.3.4.

$$E = V_T/C$$

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. The data of AADT is adjusted with regard to seasonal fluctuation but not yet available. This rate (E) was tentatively calculated for all slopes of which countermeasures works are necessary (317 slopes) for the comparison with the total score of risk rating. The result of calculation for slopes of which risk priority ranking is "Very High" and "High" is shown in Table 5.3.1.

The values of $V_T/C$ are larger than the ones of B/C but change proportionately with them. The histogram of $V_T$ /C, the relations between total score and $V_T$ /C and between B/C and $V_T$ /C are shown in Appendix 5.3.6 to 5.3.8 of Main Report, respectively. It could be mentioned that B/C and $V_T$ /C are closely related each other.

Table 5.3.1 Result of Calculation of $V_T/C$ for the East-West Highways (Case Study)

| Priority Ranking | No. | JKR Slope ID No. | Total Score (Risk Rating) | Type of Slope Disaster | | VT/C*1) | B/C |
|---|---|---|---|---|---|---|---|
| Very High | 1 | F04/071.50RC | 85 | 4 | 1 | 0.8 | 1.1 |
| | 2 | F04/081.15LC | 84 | 4 | 1 | 2.6 | 1.6 |
| | 3 | F04/031.46RC | 81 | 1 | 2 | 5.2 | 2.4 |
| | 4 | F04/032.08RG | 78 | 1 | 2 | 1.9 | 1.4 |
| | 5 | F04/033.30RC | 77 | 1 | 2 | 15.5 | 5.1 |
| | 6 | F04/072.68LC | 77 | 4 | 1 | 2.8 | 1.7 |
| | 7 | F04/069.52LC | 76 | 1 | - | 0.9 | 1.2 |
| | 8 | F04/031.92RC | 76 | 1 | 2 | 6.0 | 2.6 |
| | 9 | F04/050.90RE | 76 | 6 | - | 9.0 | 3.4 |
| High (a part) | 10 | F04/035.53LR | 73 | 3 | - | 1.4 | 1.1 |
| | 11 | F04/036.14LC | 70 | 4 | - | 1.1 | 1.1 |
| | 12 | F04/027.35RC | 70 | 3 | - | 9.6 | 2.3 |
| | 13 | F04/027.91RC | 70 | 1 | 2 | 8.7 | 2.1 |
| | 14 | F04/038.80RC | 70 | 1 | - | 7.1 | 1.9 |
| | 15 | F04/032.95RC | 69 | 1 | 2 | 12.3 | 2.6 |
| Route Total (317 Slopes) | | | | | | 14.3*2) | 1.6 |

Note: *1) " $V_T$ " means the sectional daily traffic volume of the route. $V_T$ = 1,808 vehicles/day. " C " means the cost countermeasures.

*2) was derived from dividing " $V_T$ "(1,808) by the average cost of countermeasures of all slopes in the route (126.4 RM 1,000)

### 5.3.2 Purpose and Significance of Economic Analysis

In the current system SMS and SPRS, the priority of slope in countermeasure implementation plan has been decided based on risk rating which is determined from hazard rating and consequent attributes.

It is recommended by JICA study team to introduce the economic analysis into SIMS, as it can provide give useful information to support the final decision making in implementation planning. The significance of the economic analysis includes;

1) Accountability to the people

2) Improvement of Effectiveness of Countermeasures

3) Reinforcement of Objectivity of Judgement for Priority Ranking, and so on.

### 5.3.3 Methodology of Economic Analysis

With- Without Method

With-without method is a most standard method employed in economic analysis. In this method, the benefits between the two cases; "With-The-Project" and "Without-The-Project", are compared each other and the differences are considered to be the benefits of implementation of the project.

"With-The-Project" means that the countermeasure works will be implemented while "Without-The-Project" means that the countermeasure works will not be implemented. The items of benefits are as shown in Table 5.3.2.

Table 5.3.2 Items of Benefits

| | |
|---|---|
| 1. Damages for Human Bodies | (1) In Vehicles (Injures and Death) |
| | (2) In Building Alongside Roads (Injury and Death) |
| 2. Damages for Assets | (1) Vehicle by Type |
| | (2) Buildings Alongside Roads |
| | (3) Agricultural Products Alongside Roads |
| 3. Cost for Recovery Works | |
| 4. Loss of Time and Cost of Passenger and Freights by Vehicle Type for Alternative Roads | |
| 5. Construction Cost of By-Pass Road | |
| 6. Loss Time during Road Closure | |
| 7. Damages for Business Income and Others | |

Assumptions

Some of the assumptions in analysis are shown as below:

1) The Period for Economic Evaluation: Assumed to be twenty one years
2) Probability of Occurrence of Slope Failure (Return Period): Assumed based on risk rating score of each slope; 5 years (very high), 10 years (high), 20 years (moderate) and 30 years (low).
3) Cost of Recovery Works: The repair works is assumed to occur on the basis of return period. The repair work cost is distributed equally in twenty years.
4) Loss Time During Road Closure: assumed to be dependent on failure volume.
5) Economic Cost: Economic cost and operation/maintenance cost were assumed.
6) Opportunity Cost of Capital: Three kind of economic indicator was studied; - EIRR (Economic Internal Rate of Return), B/C Ratio (Benefit Cost Ratio), and NPV (Net Present Value). The opportunity cost of capital as the cut-off-ratio in this Study is assumed to be 10 % by taking account of the opportunity cost of capital for project of road safety in Malaysia.
7) Economic Evaluation by Type of Slope Failure: The damage of slope disaster is assumed to be dependent on the quantity of failed material, which is to be defined by the type of slope failure.

### 5.3.4 Result of Economic Analysis

The result of economic analysis is figured out as the indicators such as EIRR (Economic Internal Rate of Return), B/C (Benefit Cost Ratio) and NPV (Net Present Value: B-C).

The criteria of judgment for EIRR and B/C are defined as shown in Table 5.3.3, where NPV is not shown, as it is not a ratio as EIRR nor B/C, but a amount of money. NPV is useful when there is no difference in criteria between B/C and EIRR.

Table 5.3.3 The Definition of Judgment for Indicators

| Judgment for Project | EIRR | B/C |
|---|---|---|
| Good (Highly Feasible) | More than 18% | More than 2.0 |
| Fair (Feasible) | 10-18% | 1.0 – 2.0 |
| Poor (Non-Feasible) | Less Than 10% | Less than 1.0 |

The result of the economic analysis, which was carried out on the slopes rated as Very High or High in the Case Study, is shown in Table 5.3.4 as below,

Table 5.3.4 Result of Economic Analysis for the East-West Highways (Case Study)

| Priority Ranking | No. | Chainage | Risk Rating | Type of Slope Disaster | | EIRR (%) | Benefit (RM 1,000) | Cost (RM 1,000) | B/C | NPV (B-C) (RM 1,000) |
|---|---|---|---|---|---|---|---|---|---|---|
| Very High | 1 | 071.50RC | 85 | 4 | 1 | 11.7 | 2,407.4 | 2,136.5 | 1.1 | 271 |
| | 2 | 081.15LC | 84 | 4 | 1 | 17.3 | 1,047.8 | 639.9 | 1.6 | 408 |
| | 3 | 031.46RC | 81 | 1 | 2 | 23.7 | 742.7 | 314.2 | 2.4 | 429 |
| | 4 | 032.08RG | 78 | 1 | 2 | 15.4 | 1,264.8 | 875.7 | 1.4 | 389 |
| | 5 | 033.30RC | 77 | 1 | 2 | 43.3 | 541.1 | 106.3 | 5.1 | 435 |
| | 6 | 072.68LC | 77 | 4 | 1 | 17.9 | 1,004.9 | 593.7 | 1.7 | 411 |
| | 7 | 069.52LC | 76 | 1 | - | 12.1 | 2,154.2 | 1,855.6 | 1.2 | 299 |
| | 8 | 031.92RC | 76 | 1 | 2 | 25.4 | 703.1 | 272.7 | 2.6 | 430 |
| | 9 | 050.90RE | 76 | 6 | - | 31.7 | 620.5 | 182.2 | 3.4 | 438 |
| High (a part) | 10 | 035.53LR | 73 | 3 | - | 11.6 | 1,292.5 | 1,155.0 | 1.1 | 137 |
| | 11 | 036.14LC | 70 | 4 | - | 10.9 | 1,581.2 | 1,488.1 | 1.1 | 93 |
| | 12 | 027.35RC | 70 | 3 | - | 23.4 | 395.4 | 171.1 | 2.3 | 224 |
| | 13 | 027.91RC | 70 | 1 | 2 | 21.7 | 401.7 | 189.1 | 2.1 | 213 |
| | 14 | 038.80RC | 70 | 1 | - | 19.8 | 442.6 | 232.6 | 1.9 | 210 |
| | 15 | 032.95RC | 69 | 1 | 2 | 25.6 | 349.3 | 134.0 | 2.6 | 215 |

### 5.3.5 Future Tasks for Improvement of Economic Analysis

The major tasks to improve the economic analysis for future are considered as below:

- Simplification of Calculation Procedure
- Reflection of Professional Opinion for Countermeasures
- Review of the Relationship Between the Failure Volume and Loss Time
- Relationship Between the Failure Volume and the Return Period
- Estimation of Damages for Building and Agricultural Product
- Assumption of Alternative Roads

### 5.3.6 Effective and Sustainable Management of Economic Analysis

To maintain an effective economic analysis in the road slope disaster management, training of staffs, slope disaster recording, and updating of data (slope risk rating, traffic volume, other economic development indicators etc.) are indispensable.

## 5.4 Future Development of SIMS

The design and development intent of SIMS is for universal use across Malaysia. Beyond the project study areas, SIMS is expected to be deployed and used by JKR at its Headquarters and at multiple district/ local / zonal offices. The future deployment of SIMS to these multiple locations over all of Malaysia will require a more extensive slope information database, possible expansion of the standard information tables in the application, and extensive GIS data covering the additional federal highways.

### 5.4.1 Regional Scope

Expanding the scope of the use of SIMS from the project study area to a larger regional extent will require additional information to be collected through detailed slope inspection procedures as provided for by this study. While the current standard information in SIMS may be adequate to assist in the data entry of information on new slopes, it is possible that the standard data may have to be enhanced.

Using the administrative functions provided for in SIMS, the underlying design of the database provides for flexibility in adding/changing the standard information and scoring systems, which drive the data assimilation, risk rating, and other calculation functions in the application. As SIMS is more extensively used, these standard tables can be expanded to address conditions not experienced in the Project Study Areas.

To define the slope features and generate GIS data for them, new slope polygons will have to be defined and created. For initial identification of slope feature boundaries, the field investigation teams will require current aerial photography of the additional areas under consideration and detailed contour maps of the same areas. The aerial photographs and contours will need to be added to the background GIS data in SIMS.

Slope features drawn-up on the contour maps (at possibly 1:5,000 scale) will be digitised and entered into the GIS dataset as ArcView shape files, with the attributes of each slope feature mapped relating it to the SIMS Slope Information database. Through the GIS Module, these new slope feature polygons and the database information can be inter-linked, making the entire functionality of SIMS applicable for an expanded regional applicability.

### 5.4.2 Institutional Aspects

In its expanded regional scope of use, the SIMS application will require institutional support for additional data collection and integration of information. This may be handled internally through additional expertise and additional staff at JKR or possibly through well-defined external contracts that are assigned and managed for information collection at a district highway management level.

In addition to the resources and support required for data collection, the data input into SIMS, training of additional SIMS users, and technical support (system maintenance and user support) for SIMS will be required for effective regional deployment.

It would enhance the effective use of SIMS if the value of technological awareness at JKR was further recognised by increasing the awareness of GIS, software applications, and databases technologies at all levels of professional expertise. Recognizing the benefit of these technologies to more effective departmental functioning, administration, and governance, professionals with domain expertise in technology and an understanding of departmental activities and functions are equally important to the more effective use and deployment of SIMS and other similar systems at JKR.

### 5.4.3 Technological Aspects

The application of designed software solutions like SIMS are intended to assist JKR in more effectively addressing work activities such as Slope Disaster Management. This system brings together the technology of database, GIS, and customised software and the integrated expertise of the members of the JICA Study Team and the JKR Road Maintenance Unit.

The current system is designed using Visual Basic, a relational database (SQLServer for HQ and MS Access 2000 for individual installations), and ESRI's MapObjects for GIS Functionality, for operation on a Windows 2000 based operating system. This technology and the current design of SIMS will be equally effective to address a larger regional deployment of SIMS to all of Malaysia. Limitations in its use may arise from the need for additional software licenses of MapObjects if the total number of installations exceeds 20, and from the need for additional storage capacity should the slope data increase beyond projected expectations.

The awareness and expertise in the professional domain of technology such databases, GIS, and software applications will, however, require increased in-house resources and participation of the private sector, or a combination of both. Additional training, more extensive use, and active participation of a larger number of users will increase the understanding of SIMS and the related technologies. Specific training and exposure to GIS technologies, outside of the SIMS application, will facilitate a better understanding of and application of GIS to Slope Disaster Management by JKR, as well as to other activities of the Road Maintenance Unit.

Future changes in computing technology, operating systems, and supporting infrastructure could have possible implications on the continued and effective use of SIMS. It is not feasible to predict these technological changes and the efforts required to address them, however it must be recognized by JKR that continued participation of informed expertise in the use, maintenance, and possible enhancement of SIMS will be required.

# CHAPTER 6 ORGANIZATION AND HUMAN RESOURCES DEVELOPMENT

This chapter consists of following two sections as below:

6.1 Existing Organization and Human Resources

6.2 Proposed Organization and Human Resources Development

## 6.1 Existing Organization and Human Resources

### 6.1.1 Existing Organization

(1) National disaster prevention organization

The national disaster committee is organized under the Prime Minister's Department, being composed of members representing most of the Ministries and Departments including Ministry of Works, JKR and SMART (Special Malaysian Disaster Assistance and Rescue Team). This committee handles matters related to major disasters requiring rescue and recovery systems. Road slopes will have connection to the national committee only in respect of large-scale disasters like floods and regional landslides.

(2) Organization of JKR Road Branch

The organization charts of JKR and Road Branch are shown in Figure 6.1.1 to 6.1.3. There are 125 District offices under the state offices. Under Director of Road Branch, there are five Units including the Road Maintenance Units *(The East-West Highways Unit, one of the Road Branch units, was closed by privatization in Feb. 2001).* The number of staff of the Road Branch and Road Maintenance Unit at headquarters is 510 and 24, respectively.

The Road Maintenance Unit consists of three sectors under Senior Superintending Engineer, such as (i) Slope Maintenance and Management, (ii) Mechanical and (iii) Pavement Management. The total number of staff for the federal road maintenance including slope maintenance is approximately 500 for federal roads in Jan. 2001. These staff are involved in full time road maintenance. But if there would be occasionally shortage of staff for road maintenance, the staff of other sections such as bridge and pavement would work temporarily for road maintenance. These staff who are potential temporary workers in a sense are approximately 250 for federal roads. Thus, the total number of staff engaging in road maintenance works is assumed to be 600 to 800 approximately. The actual work for road maintenance and slope management is actually conducted by 14 State Offices and 2 Federal Territories Offices, and District Offices under those offices.

(3) Organization of the Case Study Route

Along with the privatisation of the management work of the East-West Highway at the end of February 2001, two offices for this highway in Gerik and Jeli were closed. The road management work that had been previously undertaken by Gerik office was transferred to Hulu Perak District Office, Perak State. Hulu Perak District Office is composed of two Units and five sectors. Unit 1 is composed three sectors, which are (i) Road Division, (ii) Quality Division and (iii) Sub-District Division; Gerik Office, Pengkalan Hulu Office and Lenggong Office. The organization chart of the Head Office of Hulu Perak District after privatisation is shown in Figure 6.1.6.

(4) Privatisation

1) Characteristic of Privatisation

The privatization that is undergoing in relation to road maintenance is actually "the long-term contract" (15 years) with regard to taking over the maintenance work as well as the maintenance staff by the private contractors, with the exception of slope maintenance.

2) Change of Organization

After privatisation, the staff for slope maintenance will be reduced and slope maintenance work will be outsourced to private contractors and consultants.

3) Area of Privatisation

The privatization was implemented only for the Peninsula Malaysia and does not include the States of Sabah and Sarawak, and Labuan (Federal Territory)

4) Scope of Work outsourced to the Private Maintenance Companies

The scope includes, (i) Routine road maintenance; pavement, grass cutting, etc., (ii) Periodic maintenance works, (iii) Emergency actions, and so on.

5) Major Advantages of Privatization

The major advantages are thought to be (i) Reduction of personnel cost, (ii) Faster maintenance works by simple procedure, and (iii) Quality improvement of road maintenance and others.

6) Further Plan of JKR for road maintenance

JKR is now proposing a plan to the Government to establish a new organization to administer all road maintenance work that was contracted to private companies. Until getting approval for such a new organization, the private maintenance work has been monitored by the UPPJ (Road Maintenance and Management Unit) that was set up by JKR in each state office.

(5) Slope Maintenance and Management

1) Ordinary Situation: Currently the slope of the federal roads is managed using SPRS (Slope Priority Ranking System), introduced in 1999. Slope inspection is carried out by trained technicians of District offices, in accordance with the JKR USJ 1/2000 form. The result is sent to the headquarters and after evaluation of the risk and priority, a final decision is made for the implementation program and budgeting. Routine Slope Inspection is carried out by district technicians at least

once a year. Confirmatory slope inspection is carried out randomly by headquarters' engineer for data audit. When necessary, special inspection is carried out by geologist or geo-technical engineer.

2) Emergency Situation

With privatisation, emergency work was transferred to the scope of the concession maintenance companies, including rescue and evacuation of affected people and clearance of rock and debris for traffic passage. The non-urgent repair work is managed later by JKR after proper assessment of risk and urgency with the engineering and construction work outsourced to engineering company/contractor through bidding procedures.

3) Budget for Slope Maintenance

According to the year 2000 budget, total cost for road maintenance is RM 330 million. About RM 65 million, or 20% of this, is allocated to slope maintenance. The slope maintenance cost is composed of emergency cost, routine maintenance cost and others. But the emergency cost occupies about 50% of total cost of slope maintenance.

From the year 2002 on, a 'special requirement' scheme is implemented in which large slope repair projects of more than RM 2 million can be individually applied for through the Ministry of Works.

4) Necessity of Close Relation between JKR and Private Maintenance Company

Close relation should be maintained between JKR and maintenance company, in connection with information exchange and prompt necessary action to observe the stability of slope and to avoid possible disaster caused by slope failure.

### 6.1.2 Existing Human Resources

(1) JKR

1) The number of staffs for Slope Maintenance

At the JKR headquarters, the number of staff of the Road Branch is 510, and that of the Road Maintenance Unit at headquarters is 24. The total number of staff engaging in road maintenance works at state offices and district offices nationwide is assumed to be approximately 600 to 800.

2) Skilfulness of Staffs

In the report of "Slope Management System in JKR" presented at the 4th Malaysian Road Conference, Oct.-Nov. 2000, it is pointed out that there has been a lack of geotechnical considerations during past and recent construction of roadside slopes. From this, it is evaluated that most of the engineers in JKR have already acquired general engineering knowledge necessary for road management tasks, however, as far as slope management is concerned, most of them do not have sufficient professional knowledge of geology or geotechnical engineering.

(2) Private Sectors

Human resources in the private sector, including contractors, consultants and other institutes, has improved in recent years in the area of road and slope engineering, in respect of the number and skilfulness of professionals. Under the government policy of privatisation, this trend is expected to continue. Thus, the shortage in number and quality of human resources in the said area can be supplemented by making use of human resources from the private sector.

## 6.2 Proposed Organization and Human Resources Development

### 6.2.1 Proposed Organization

After privatization, the road maintenance staff, especially of the district office, have moved to the private companies, while the slope management staff still remain in the district office. In this context, it is an important task for the headquarters to separate the managerial core works done by itself from the works to be shared by local offices and to be outsourced to private companies as listed below:

(1) Decentralization of Control Function of the Headquarters

With the increasing roles of the Maintenance Unit staffs due to higher technical requirements and expanding coverage of federal roads, it is recommended to shift some of the duties to the relevant state office and district office.

(2) Strengthening of Slope Disaster Management Functions

Currently Slope Maintenance and Management Sector, Road Maintenance Unit, is in charge of slope disaster management of federal roads in the country. It is recommended to strengthen the capability of slope disaster management, by addition of specialist in the area of slope risk evaluation and system maintenance.

(3) Implementation of New Slope Management System

There are still many slopes likely to fail in the country. It is recommended to implement a slope management program to important federal roads, as soon as possible, to prevent possible disasters, which should include slope inspection and slope risk evaluation using the newly developed information system (SIMS). Outsourcing should be efficiently used for most of the works for implementation of SIMS and database development.

(4) Establishment of Economic Research Section

For reasonable decision-making and accurate costing system, economic research should be emphasized. For these purposes, a special section for economic research is recommended to establish in JKR.

### 6.2.2 Proposed Human Resources Development

The human resources have to be suitably allocated to the positions in the organization to achieve their roles. Therefore, human resources development must be conducted in principle by taking account of the basic strategies and the proposed improvements to the organization as mentioned in 6.2.1. After privatization, most of the staff for road maintenance work were shifted to the private maintenance companies, except for management staff in headquarters. Therefore, the human resources development work must be focused on slope management as follows.

(1) Training program for Slope Disaster Management

Training program should be arranged to increase the capability of JKR staff for slope disaster management. OJT (On-Job Training) may be used for familiarization of actual procedures. Training program should be arranged both for the staff of the headquarters and local Offices.

(2) Assignment of Specialist in Slope Risk Evaluation in the Headquarters

Among the necessary staff for slope management, a geologist (or geotechnical engineer with geological knowledge and experience) should be assigned in the Slope Management Sector, headquarters. This specialist can work for planning and guidance for training program and slope inspection implementation plan. In case a suitable staff cannot be found in JKR, such person may be acquired at another governmental agency like JMG (Mineral and Geoscience Department) or private institutions.

(3) Assignment of Specialist in System Engineering in the Headquarters

A system engineer should be assigned in the Slope Management Sector, headquarters. This specialist can work for planning and guidance for maintenance and further development of Slope Information System (SIMS). In case a suitable staff cannot be found in JKR, such person may be acquired at another governmental agency or private institutions.

# CHAPTER 7 IMPLEMENTATION OF SLOPE MANAGEMENT SYSTEM



## 7.1 Implementation to Nationwide Federal Road

(1) Background

SPRS (Slope Priority Ranking System) is currently applied to most of the federal roads in Malaysia. Although it is quite a functional system for nationwide slope management, there are some deficiencies in areas like reliability of hazard rating, slope database, and map function. As a result, SIMS has been developed through the JICA-JKR cooperative study and this section describes a proposed plan for its nationwide implementation to federal roads.

(2) Priority in Implementation

The total length of federal roads in Malaysia is 14,891 km. Taking the work force and financial allocation into consideration, it is proposed to put prioritise the roads within the implementation program. Table 7.1.1 shows a list of 12 selected federal roads identified as prone to slope disaster, based on the result of SPRS. *(The core of this table was prepared and disclosed by JKR in a news paper in July 2000. Route No.6, Pulau Pinang Road, was not included in the announcement, but later added in consideration of its high risk of rock fall).*

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.

(3) Proposed Implementation Plan of Phase-I

1) 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 |

2) Scope

The scope of work consists of slope inspection, SIMS development (system customisation and database establishment), and slope maintenance and disaster management system

3) 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.

4) Outsourcing

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

5) 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.

6) 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.

7) Proposed Schedule of Implementation in Phase-I

The proposed implementation for Phase I is shown in Table 7.1.2.

Table 7.1.1 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)*

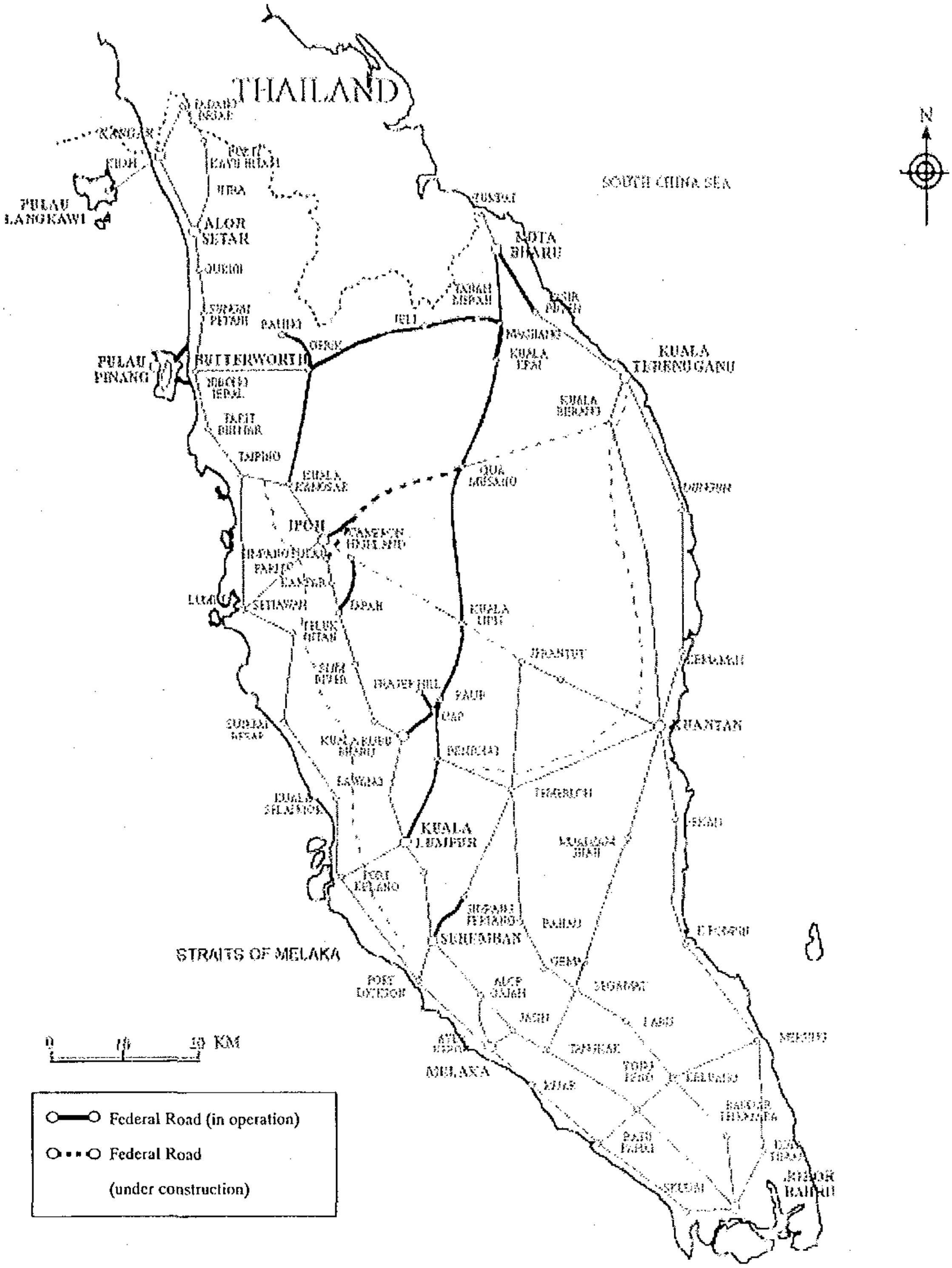



Figure 7.1.1 Federal Roads Identified as Prone to Slope Disaster (Peninsula)

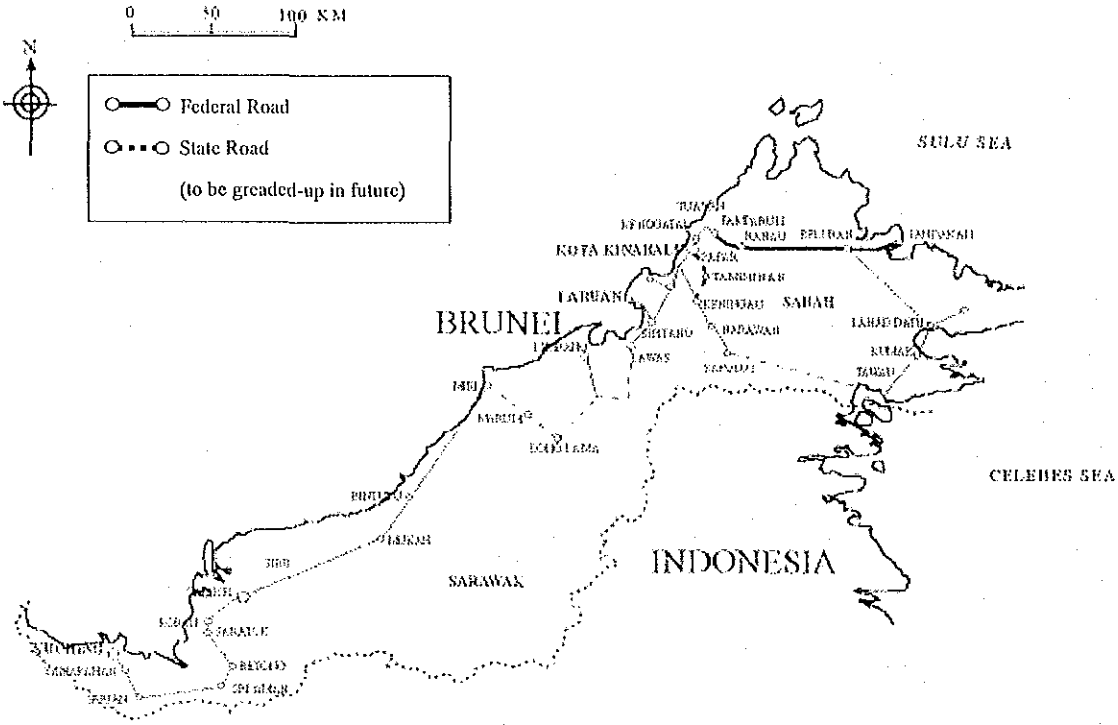



Figure 7.1.2 Federal Roads Identified as Prone to Slope Disaster (East Malaysia)

Table 7.1.2 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 | | | = = = | ══ | | | = = = | ══ | |

## 7.2 Human Resources for Implementation

### 7.2.1 Expected Functions for JKR as Core Competence

(1) Road Maintenance Unit, Headquarters

The Slope Maintenance and Management Sector, of the Road Maintenance Unit is in charge of slope disaster management. The sector consists of three engineers and three supporting staff.

In connection with the implementation of SIMS, this section should be responsible in implementation, maintenance and future development of SIMS, together with arrangement of training program.

(2) Information and Technology Centre (ITC), Headquarters

ITC belongs to the Planning and Corporate Service Branch. Among many units of ITC, technical support from the Mapping & Infrastructures and Utilities Sector is thought as quite beneficial to maintenance and further development of SIMS.

(3) State Office

The State Offices are expected to have management and intermediate functions between headquarters and district offices for slope disaster management.

(4) District Offices

The District Offices are expected to have various functions as core competencies with regard to slope disaster management; which include regular patrol of slopes, maintenance of the slope-related database, supervision of slope inspection, investigation, repair work done by subcontractors, emergency action and so on. In particular, maintaining close links with the privatised road maintenance company will be very important for slope disaster management.

### 7.2.2 Human Resources to be Outsourced

(1) Purpose of Accelerating Outsourcing

1) Organizational Strategy:

Concentration of know-how and human resources to core competence is one of the most important purposes of the organizational strategy for outsourcing..

2) Financial Efficiency Strategy

Cost reduction is one of the most common reasons for the introduction of outsourcing. To convert the fixed cost of non-core works into variable cost would also contribute to cost reduction.

3) Technical Strategy

Outsourcing from the viewpoint of technical strategy aims to strengthen the professional knowledge and to acquire the latest technology by utilizing professional experts outside of JKR. This purpose is extremely important for information technology concerning SIMS.

(2) Human Resources to Be Outsourced

The following roles or specialties are now short-staffed in JKR and should be outsourced.

1) Slope Inspection

Slope Inspection should be outsourced, although at present periodical slope inspection is done by JKR district officers. This will have benefits in terms of personnel cost reduction and utilization of expertise of specialist.

2) Slope Information Management System (SIMS)

The following skills and work items would be required to be outsourced to a local contractor as important tasks of operating SIMS

- System maintenance of SIMS
- Map creation (including aerial photography)

3) Emergency Work and Countermeasure Work (Repair Work)

Although most of the work has been outsourced to private companies, more efficient and reliable work of outsourcing should be continuously studied.

These works include:

a) Emergency response: Clearance of fallen debris, etc
b) Engineering: Topographical Survey, Soil Investigation and Design
c) Countermeasure Work (Repair Work): Construction of slope works
d) Monitoring and analysis of rainfall/ slope behaviour

4) Staff Consultancy System

It is recommended to introduce a staff consultancy system in slope disaster management. Registered consultant can give site visit and technical advice for JKR upon request. Such system has been introduced by IRDB, ADB and Japanese government. (In Japan such specialist is registered by the government as "Disaster Prevention Expert".)

## 7.3 Training Programme

The suggested training programme for implementation of the newly developed slope disaster management is shown in Table 7.3.1. The training program consists of three courses:

(1) Slope Disaster Management
(2) Slope Inspection
(3) SIMS Operation

The outline of each course is presented as follows.

(1) Course of Slope Disaster Management

This course is prepared only for JKR staff who will be involved with road slope disaster management. The contents should be the comprehensive and basic guidance for slope disaster management, including the general management of slope disasters, slope inspection, slope countermeasure selection and cost estimation, and SIMS application. The main materials for this course will be "Guideline I: Guide to Road Slope Maintenance and Disaster Management" prepared by the JICA Study Team.

(2) Course of Slope Inspection

The course is prepared for JKR staff of the headquarters, State and District offices, and also engineers from geotechnical companies. The guidance and/or site training (OJT) will be given regarding the basic principles and actual procedures on the basis of "Guideline II: Guide to Slope Inspection" and "Guide IV: Guide to Countermeasure Selection and Cost Estimation". The instructors of this course could be a combination of JKR staff and specialists from other agencies.

(3) Course of SIMS Operation

The course is designed for both JKR staff (headquarters, state office and district office) and engineers of the systems company who will be involved with the system operation of SIMS. The guidance and/or site training (OJT) will be given regarding the basic principles and actual procedures of SIMS operation on the basis of "Guideline V: Guide to Slope Information Management System (SIMS)". The instructors of this course could be a combination of JKR staff and specialists from other agencies.

Table 7.3.1 Training Program for Slope Disaster Management

| Item for Training | | | Slope Disaster Management | Slope Inspection | SIMS Operation |
|---|---|---|---|---|---|
| Training Materials | | | -*Guideline I:*<br>"Guide to Slope Maintenance and Road Disaster Management" | -*Guideline II:*<br>"Guide to Slope Inspection"<br>-Guideline IV:<br>"Guide to Slope Countermeasure Selection and Cost Estimation" | -*Guideline V:*<br>"Guide to Slope Information Management System (SIMS)"<br>-Separate Volume depending on User Level |
| *Instructor for guidance and OJT* | | | -Engineer in Road Maintenance Unit | - Engineer in Road Maintenance Unit<br>- Geotechnical Engineer/geologist from other organization | -Engineer in Road Maintenance Unit<br>- System Engineer from other organization |
| Trainee & Training Scheme | JKR H.Q | Slope Maintenance and Management Sector | -Guidance to Engineer | -Guidance to Engineer and Technician | -Guidance and OJT as **Expert User Level** to Engineer<br>- Guidance and OJT as **General User Level** to Technician |
| | | IT Center | -Guidance to Engineer | No need (If available, self-teaching the baseline knowledge by reference to GuideII and GuideIV) | -Guidance and OJT as **Administrative User Level** to Engineer and Technicaian |
| | JKR State Office | | -Guidance to Engineer | -Guidance to Engineer | -Guidance as **General User Level** to Engineer |
| | JKR District Office | | -Guidance to Engineer | -Guidance and OJT to Engineer and Technician | -Guidance and OJT as **Expert User Level** to Engineer<br>- *Guidance and* OJT as ***General User Level*** to Technician |
| | Private Sector for Sub-Contract | Geo-technical Company for Initial Inspection Work | No need | -Guidance and OJT to Geologist/Geotechnical Engineer and Civil Engineer | No need (If available, self-teaching the baseline knowledge by reference to GuideV) |
| | | *System Company for* System Maintenance | No need | No need (If available, self teaching the *baseline knowledge by reference to GuideII* and GuideIV) | -Guidance as **Administrative User Level** to *System Engineer* |

# CHAPTER 8 GUIDELINES FOR ROAD SLOPE DISASTER MANAGEMENT



The objectives of the preparation of the guidelines were for it to be primarily;

1) A guide for JKR staff at headquarters and relevant local offices to implement the new slope management system in managerial and technical aspect.
   However, the guidelines may be usable as;
2) A technical reference for people in the private sector who will be involved with works in the slope management program.

The contents of each Guide are summarized in Table 8.1.1 as below. As shown in the table, Guide I offers an overview of road slope management and the procedures for maintenance and management work. Guides from II, III and IV describe the details of the concepts, specification and procedure of each specific field. Guide V is designed to serve as the user's reference for 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 | a) Overview of slope management<br>b) Suggested procedures of slope maintenance and management. |
| Guide II: | Guide to slope Inspection | Technical guide; the concept and 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. |

Although this guide was prepared for application to the federal roads in Malaysia, taking the actual technical and socio-economical conditions of the country into account, it should be reviewed periodically by JKR and local experts so that it may better fit the local conditions.

## 8.1 Guide to Road Slope Maintenance and Disaster Management (Guide I)

Guide I consists of eight chapters. The main points of each chapter are:

Chapter 1: Preface

Background and objective of preparation of the Guideline is described.

Chapter 2: Outline of Road Slope Disaster Management

The mission, basic concept and workflow of road slope management is described. Also, the relationship between each of Guides I to V is explained.

Chapter 3: Organization for Road Slope Disaster Management

Organization for road management, recent privatisation of routine road maintenance, and the necessity for cooperation between concerned parties is described. In particular, the necessity for close relationship between the private maintenance companies and JKR is emphasized.

Chapter 4: Slope Inspection and Risk Rating

An outline of slope inspection and risk rating is described. (The details of slope inspection and risk rating are handled by Guide II.)

Chapter 5: Implementation of Countermeasure

Basic concepts and procedure of prioritising countermeasure implementation is described. (The details of slope inspection and risk rating is handled by Guide IV.)

Chapter 6: Slope Maintenance

Outline and actual procedure of slope maintenance is described. In particular the importance of regular patrols with special attention to slope and recording system of patrol, disaster events and repair work history are emphasized.

Chapter 7: Early Warning and Traffic Control

The concept and suggested standard criteria of early warning and traffic control is described, with emphasis on the usefulness of these systems in road slope disaster management. (The details of early warning based on monitoring instruments are described in Guide III.)

Chapter 8: Emergency Plan

The concept of an emergency plan is described both for preparedness plan and emergency response plan. A sample plan is presented which was prepared in reference to the current system employed in road management organizations in Japan.

## 8.2 Guide to Slope Inspection (Guide II)

Guide II consists of six chapters. The main points of each chapter are:

Chapter 1: General

Slope inspection is very important in slope disaster management because it can provide the basic information for risk assessment of each slope, in other words, for priority in countermeasure implementation or other slope management program.

Regarding the execution of slope inspection, the suggested study team structure and requirements of team members is described.

Chapter 2: Scope of Work

The flow and scope of slope inspection is described. Prior to the execution of field inspection of each slope, preparatory work is essential for picking up landslides and debris flows of large scale and for screening out lower risk slopes.

Chapter 3: Slope Inspection

One of the characteristics of this guide is that field observance, risk rating, and proposal of appropriate countermeasure are all carried out in accordance with the type of failure of each slope. Six types of typical slope failure were established based on the reconnaissance survey and bibliographic study in Malaysia.

Actual procedures of slope inspection work are described in detail; including selection of inspection sheet, identification of slope failure type, and field observation and filling up of the inspection sheet. Also the manner of geological sketch and digital photograph record is specified.

Chapter 4: Method of Risk Ranking

The method of risk rating is described in detail, including hazard risk rating for each type of failure, consequence score, selection and cost estimation of proposed countermeasure.

Chapter 5: Countermeasure

Method of selection of appropriate countermeasure is described in detail with instructive flow. Also standard rates are proposed for cost estimation of countermeasures.

Chapter 6: Reporting and Data Creation

The method of reporting and data creation based on the slope inspection is described.

## 8.3 Guide to Early Warning System and Site Investigation (Guide III)

Guide III consists of two parts, Early Warning System (Chapter 1--3) and Site Investigation (Chapter 4--7).

Early Warning System (III-1)

Chapter 1: Introduction of early warning system

To prevent and minimise the road disaster caused by slope failure, an early warning system is a realistic and effective tool as many high-risk slopes are compelled to wait for countermeasure implementation due to shortage of construction budget. Two approaches of early warning system are presented,

a) Monitoring of slope movement, and
b) Observation of rainfall

Traffic control, such as total blockade, speed limitation, lane limitation, or simple warning can be enacted when the measured data surpass pre-set criteria.

Chapter 2: Recommendation for Malaysia

Tentative criteria for traffic control are proposed, both for slope movement and rainfall, for application to federal roads of Malaysia

Chapter 3: Instrumentation for early warning system

Various types of instruments that are adaptable for monitoring and early warning are introduced, including the description of installation and measurement.

Site Investigation for road slope (III-2)

Chapter 4: Introduction of site investigation

This part describes the method of site investigation to be carried out for detailed design of countermeasures for slopes at risk of failure. The investigation program is suggested in accordance with six types of slope failure.

Chapter 5: Preliminary study

Preliminary study is suggested to determine the policy of basic design.

Chapter 6: Detailed study

Scope and methodology is described on the detailed study program for detailed design of countermeasures, which depends on the type of slope failure.

Chapter 7 New technologies of investigation and monitoring

Some of the latest or special techniques of monitoring and investigation are introduced for future possible application

## 8.4 Guide to Countermeasure Selection and Cost Estimation (Guide IV)

Guide IV consists of ten chapters. The main points of each chapter are:

Chapter 1: Basic Concept of Countermeasure Works of Slope

Careful study and consideration is required for selecting an appropriate countermeasure against a possible slope failure among numerous options. Some of the important matters in countermeasure selection are described. Also, a brief explanation of slope failure type is given as it is the basis of countermeasure selection.

Chapter 2: Selection of Countermeasure

This chapter reviews various kinds of countermeasures. The applicability of each countermeasure with respect to the six types of slope failure is shown in Table 8.4.1.

Chapter 3 –8 Countermeasure against Each Type of Slope Failure

Suggested procedures for selection of appropriate countermeasure are explained by flow chart, against each type of slope failure. The reason for this is that the appropriate countermeasure largely depends on the likely slope failure.

Chapter 9: Approximate Cost Estimation of Countermeasure

The standard unit rates of most applicable countermeasures was studied and presented in cooperation with JKR and local consultants. The purpose of preparation of this table was to estimate the approximate cost of countermeasures as supporting data in implementation of planning and budget planning at JKR Headquarters. It is recommended to be reviewed periodically to reflect the actual cost as accurately as possible.

Chapter 10: Example of Countermeasure Design

Some figures/documents related to slope countermeasure design were collected out of actual cases in Japan and Malaysia, and introduced as a reference material for future slope study.

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 | Re-Vegetation | ○ | △ | × | ○ | ○ | ○ |
| | | Hydroseeding | ○ | △ | × | ○ | ○ | ○ |
| 3. WATER DRAINAGE | Surface Drainage | Drain Ditch and Cascade | ○ | △ | △ | ○ | △ | ○ |
| | | Subsoil Drainage Hole | ○ | △ | × | ○ | × | ○ |
| | Subsurface Drainage | Horizontal Drain Hole | ○ | × | ○ | ○ | △ | ○ |
| | | Drainage Well | × | × | × | ○ | × | × |
| | | Drainage Tunnel | × | × | × | ○ | × | × |
| 4. SLOPE WORK | Pitching Work | Stone Pitching | ○ | ○ | △ | × | × | ○ |
| | Shotcrete Work | Shotcrete (Concrete) | ○ | ○ | ○ | × | ○ | × |
| | | Shotcrete (Mortar) | ○ | ○ | ○ | × | ○ | × |
| | Crib Work | Cribwork (Precast) | △ | △ | × | △ | × | ○ |
| 5. ANCHORING | Anchoring | Soil Nailing | ○ | △ | × | △ | △ | ○ |
| | | Rock Bolt | ○ | ○ | ○ | ○ | △ | × |
| | | Ground Anchor | ○ | ○ | ○ | ○ | △ | × |
| 6. WALL AND RESISTING STRUCTURES | Retaining Wall | Stone Pitching Wall | ○ | ○ | ○ | ○ | △ | ○ |
| | | Concrete Block Wall | ○ | ○ | ○ | ○ | △ | ○ |
| | | Supported Type Retaining Wall | ○ | ○ | ○ | △ | △ | ○ |
| | | Crib Wall (Precast) | ○ | ○ | ○ | ○ | △ | ○ |
| | | Pile Wall | ○ | ○ | ○ | ○ | △ | ○ |
| | Catch Work | Catch Fill | △ | ○ | △ | × | × | × |
| | | Gabion Wall | ○ | ○ | × | ○ | ○ | ○ |
| | | Catch Gabion | △ | ○ | △ | × | ○ | × |
| | | Catch Concrete Wall | △ | ○ | △ | × | △ | × |
| 7. PILLING | Pilling Work | Steel Pipe Pile | △ | × | × | ○ | × | × |
| | | H Steel Pile | △ | × | × | △ | × | × |
| | | Shaft Work for Resistance Slide | △ | × | × | ○ | × | × |
| 8. PROTECTION WORK | Protection Work | Rock Fall Catch Net | △ | ○ | ○ | × | × | × |
| | | Rock fall Catch Fence | △ | ○ | ○ | × | × | × |
| | Rock Shed | Concrete (or Steel) Shed | △ | ○ | ○ | × | ○ | × |
| | | Debris Shed | △ | △ | △ | × | ○ | × |
| | Sabo (Check) Dam | Slit Dam | × | × | × | △ | ○ | × |
| | | Concrete (or Stone) Dam | × | × | × | ○ | ○ | × |
| 9. OTHERS | Avoiding Problem Work | Diversion (Shifting) | △ | △ | ○ | ○ | ○ | △ |
| | | Route Relocation | △ | △ | ○ | ○ | ○ | △ |

○ : Applicable △ : Limited case × : Not applicable

**CL** : Collapse **RF** : Rock Fall **RM** : Rock Mass Failure **LS** : Land Slide

**DF** : Debris Flow **EB** : Embankment Failure

## 8.5 Guide to Slope Information Management System (SIMS) (Guide V)

Guide V consists of two chapters. The main points of each chapter are:

### Chapter 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 Lumpur, and multiple stand-alone installations for use in District Offices.

### Chapter 2: Overall Structure of SIMS User Guide

The SIMS Application Guide consists of the following eight sections:

2.1 Design Guidelines and Considerations
2.2 Hardware and Software Requirements for Application Operation
2.3 Application Installation Instructions
2.4 Application Modules
2.5 Administrative Functions
2.6 User Levels
2.7 Help Function
2.8 Lookup Tables and Standard Values

2.1 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.

2.2 Hardware and Software Requirements for Application Operation

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

2.3 Application Installation Instructions

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

2.4 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 districtoffices and at the headquarter office of JKR.

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

a) Slope Information, b) Hazard/ Risk Rating, c) Counter Measure,
d) Economic Analysis, e) Integrated Reporting, f) GIS Functions

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

2.5 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.

2.6 User Levels

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

a) General User, b) Advanced User, and c) Administrative User

The details and control of the user levels are 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.

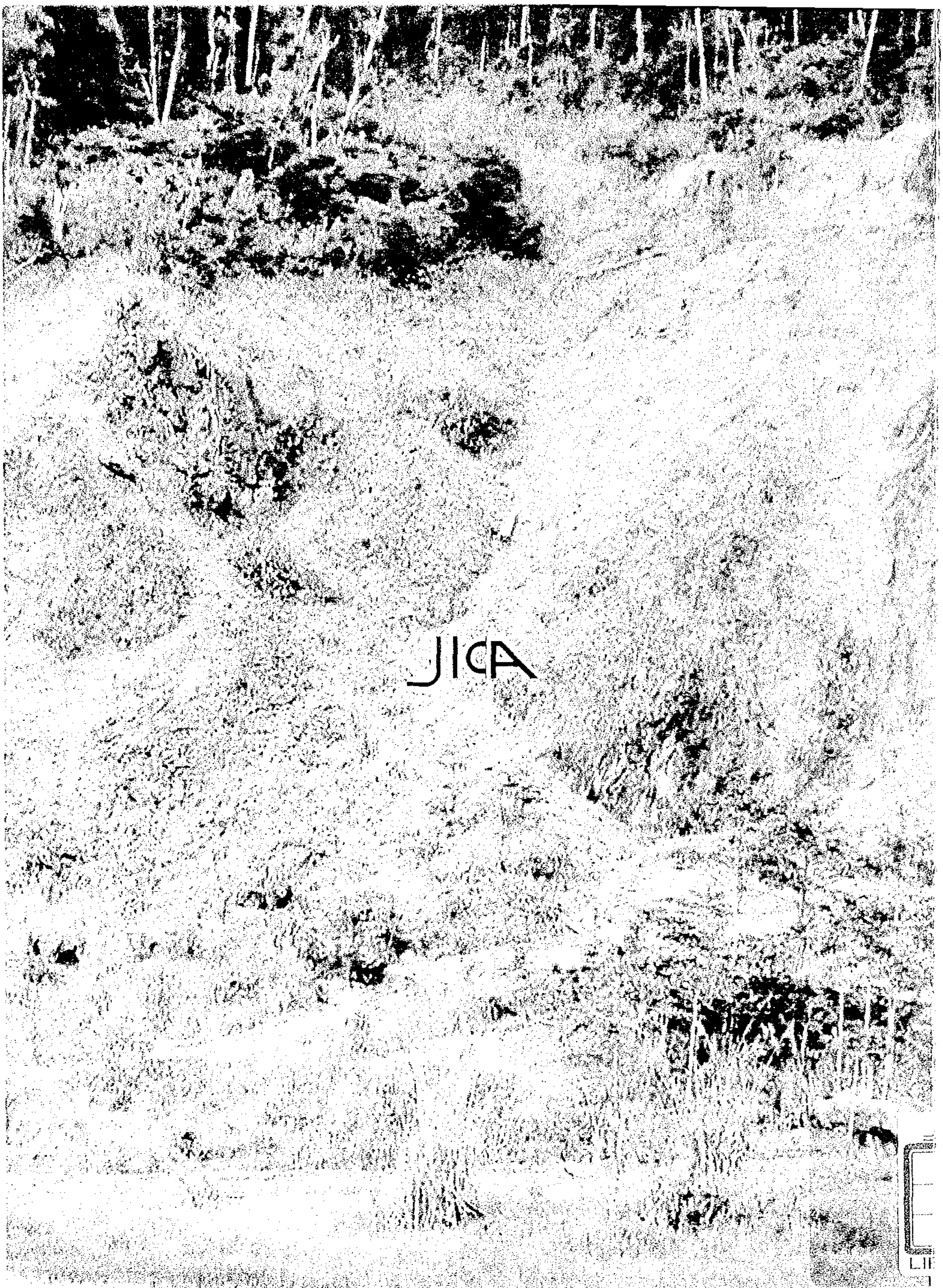
2.7 Help Function

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.

2.8 Lookup Tables and Standard Values

Lookup Tables and Standard values populate the application providing selection options to the user without having to key in 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 is provided in this section of the guide.


JICA