JAPAN INTERNATIONAL COOPERATION AGENCY
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON RISK MANAGEMENT FOR SEDIMENT-RELATED DISASTER ON SELECTED NATIONAL HIGHWAYS IN THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT

VOLUME I

EXECUTIVE SUMMARY

JUNE 2007

NIPPON KOEI CO., LTD.

OYO INTERNATIONAL CORPORATION

COMPOSITION OF THE FINAL REPORT

Volume	Report Name	Language
Volume I	EXECUTIVE SUMMARY	English
Volume II	MAIN REPORT	English
Volume III	EXECUTIVE SUMMARY	Japanese
Guide I	GUIDE TO RISK MANAGEMENT PLANNING ON ROAD SLOPES	English
Guide II	GUIDE TO INVENTORY SURVEY AND RISK ASSESSMENT ON ROAD SLOPES	English
Guide III	GUIDE TO ROAD SLOPE PROTECTION	English

PREFACE

In response to a request from the Government of the Philippines, the Government of Japan decided to conduct the Study on Risk Management for Sediment-Related Disaster on Selected National Highways and entrusted it to the Japan International Cooperation Agency (JICA).

JICA selected a study team, composed of Nippon Koei Co., Ltd. and OYO International Corporation, headed by Mr. Yuichi Tsujimoto. The study team was dispatched to the Philippines from March 2006 through June 2007.

The team carried out the study in close joint work with the officials concerned of the Government of the Philippine and through a series of discussions with them, developing a road slope risk management system named RSMS, conducting a pilot inventory survey on slopes along selected national highways, and doing some model feasibility studies on countermeasures against the slope disaster. Upon returning to Japan, the team compiled the results of the study as this final report.

I hope that this report will contribute to the promotion of effective risk management of road slopes and to the enhancement of friendly relationship between our two countries.

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

June 2007

Kazuhisa MATSUOKA
Deputy-President
Japan International Cooperation Agency

June 2007

Mr. Kazuhisa Matsuoka
Vice-President
Japan International Cooperation Agency (JICA)

LETTER OF TRANSMITTAL

Dear Sir,

It is our great pleasure to submit to you the final report of the "The Study on Risk Management for Sediment-Related Disaster in Selected National Highways in the Republic of the Philippines".

The report contains the results of the study undertaken by the study team comprising Nippon Koei Co., Ltd. and OYO International Corporation jointly with the counterpart team of the Department of Public Works and Highways (DPWH) of the Government of the Philippines from March 2006 to June 2007.

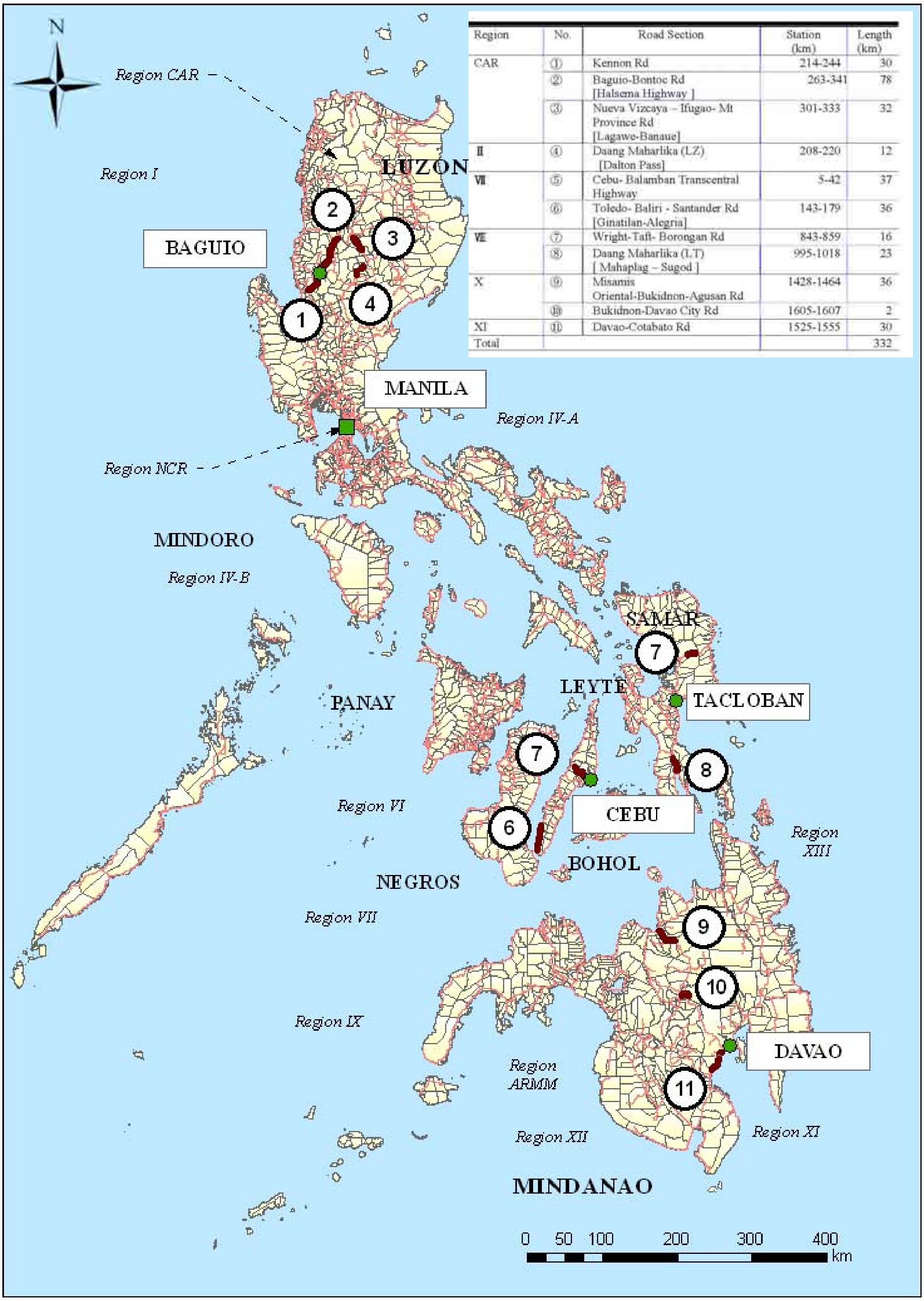
We firstly thank the officials of your Agency, including the members of your Philippine Office as well as the Experts being dispatched to DPWH, for their valuable advice and assistance given to the study team throughout the course of the study.

For accomplishment of the study, besides valuable comments and suggestions from the members of the Steering Committee and Technical Working Group established in DPWH, many people of the Central Office, Regional Offices and District Engineering Offices of DPWH extended their kind assistance and cooperation to the study team in many places in the Philippines. In concluding the study we would like to express our sincere appreciation to all of them, particularly those of the Development Planning Division of the Planning Service.

We deeply wish that the results of our study would contribute to early development of an effective, nationwide risk management system for the slopes along national highways of the Philippines.

Very truly yours,

Yuichi Tsujimoto
Team Leader
The Study on Risk Management for
Sediment-Related Disaster on Selected
National Highways in the Republic of
the Philippines



Region	No.	Road Section	Station (km)	Length (km)
CAR	①	Kennon Rd	214-244	30
	②	Baguio-Bontoc Rd [Halsema Highway]	263-341	78
	③	Nueva Vizcaya – Ifugao- Mt Province Rd [Lagawe-Banaue]	301-333	32
II	④	Daang Maharlika (LZ) [Dalton Pass]	208-220	12
VII	⑤	Cebu- Balamban Transcentral Highway	5-42	37
	⑥	Toledo- Baliri - Santander Rd [Ginatilan-Alegria]	143-179	36
VIII	⑦	Wright-Taft- Borongan Rd	843-859	16
	⑧	Daang Maharlika (LT) [Mahaplag – Sugod]	995-1018	23
X	⑨	Misamis Oriental-Bukidnon-Agusan Rd	1428-1464	36
	⑩	Bukidnon-Davao City Rd	1605-1607	2
XI	⑪	Davao-Cotabato Rd	1525-1555	30
Total				332

LOCATION MAP OF THE INVENTORY SURVEY

SYNOPSIS

1 INTRODUCTION

Objectives of the Study were: a) Development of a road slope inventory survey system, b) Creation of a road slope database system, c) Formulation of a systematic road slope risk management procedure, and d) Capability enhancement of the Department of Public Works and Highways (DPWH) engineers in the assessment and management of road slope disasters.

There are 332 km of road sections selected for the preliminary inventory survey (PIS), of which 61 km have been prioritized, based on the PIS results, for implementation of pilot detailed inventory surveys (DIS). Further, five sites for the model feasibility study on the respective countermeasure have been selected.

The technical transfer during the Study period was promoted in three ways, including; 1) Joint work between the JICA Study Team and DPWH personnel, 2) On-the-job training for DPWH personnel, and 3) Seminars/Workshops for DPWH personnel.

2 OVERVIEW OF SLOPE DISASTERS ON NATIONAL HIGHWAYS

The Study Team, together with the Counterpart Team, classified road slope disasters on the national highways in the Philippines into seven (7) types, including SC, RC, LS, RS, DF, RE, and CE, taking into consideration the failure mechanism and countermeasure options for each disaster type.

A questionnaire survey on the occurrence of Road Closure Disaster (RCDs) on national highways in 2004 and 2005 revealed that the total road length with risks of road closure disaster is 1,774 km out of the 29,005 km of national highways. In 2004 and 2005, RCDs occurred 2,708 times per year on average. Losses induced by RCDs were estimated at approximately PHP 2,600 million.

The rapid development of the road network under adverse natural conditions and limited budgets has resulted in the need for more countermeasures on road slopes. Major matters to be improved on the design and construction of countermeasure on slopes include (1) Drainage work, (2) Cutting work, (3) Foundation for structures, (4) Knowledge and technology for large-scale landslide, (5) Introduction of new technology, and (6) Overall plan for the prevention of road slope disasters in the maintenance stage.

3 ACTIVITIES FOR ROAD SLOPE MANAGEMENT IN DPWH

The primary legislation on disaster management is Presidential Decree 1566 issued in June 1978. The NDCC is the primary body responsible for various facets of responding to national disasters. It serves as the President's adviser on disaster preparedness programs, disaster operations and rehabilitation efforts undertaken by the government and the private sector. Other agencies concerned with disasters include (1) Mines and Geosciences Bureau (MGB), Department of Environment and Natural Resources (DENR), (2) Philippine Atmospheric, Geophysical & Astronomical Services Administration (PAGASA), DOST, and (3) Philippine National Police.

The absence of a "Road Slope Management System (RSMS)" is evident from the existing Road and Bridge Information Applications (RBIA) where information on road condition is limited to roughness and visual observations (pavement condition). During and after each disastrous event, the District Engineering Office (DEO) dispatches its road maintenance teams to sites historically identified as potential disaster sites.

Currently, funding for road maintenance activities is wholly sourced from the Special Road Support Fund programmed by Road Program Office (RPO), from the proceeds of the Motor Vehicle User Charges (MVUC).

When the cost of the immediate response is within the financial resources of the DEO, the DEO undertakes the activity right away using its road maintenance budget. When events such as typhoons and earthquakes cause substantial damage to the road infrastructure beyond the capacity of the DEO's resources, the DEO reports the event to the DPWH Regional and Central offices for the purpose of securing the Immediate Response Fund (IRF) and the Quick Response Fund (QRF), respectively, to restore the infrastructure.

The current system for the conduct of road routine maintenance activities excludes road slopes, which are therefore not included in the estimation of the Equivalent Maintenance Kilometer (EMK). The second issue is how road slope-related maintenance activities would be funded, given that currently the financial resources allocated by the national government through the General Appropriations Act (GAA) and MVUC are insufficient. This has resulted in the continued deterioration of the national road system. The third issue is who will undertake the road-slope related maintenance activities given that the DPWH DEO does not have even the optimum manpower to undertake routine maintenance.

4 DEVELOPMENT OF ROAD SLOPE MANAGEMENT SYSTEM

Road Slope Management System (RSMS) is composed of three major components including (1) Inventory survey of road slopes, (2) Database system for road slopes, and (3) Risk management planning. To support the implementation of the three major components of RSMS, the technical "Guide" have been prepared as Guide I: Risk Management Planning, Guide II: Inventory Survey, and Guide III: Road Slope Protection.

The Inventory Survey is designed to be implemented by completing five types of templates prepared for two stages: the Preliminary Inventory Survey (PIS) and the Detailed Inventory Survey (DIS). The RSMS database has the functions such as (a) Import and export function between the Inventory Data Sheets and the Database, (b) Formulation of road slope inventory tables, and (c) Map display function of RSMS. Risk levels and feasibility indicators, which are obtained from the processed Inventory Surveys (IS) /RSMS database, are used for risk management planning.

Specific purposes of the Inventory Survey are (1) Identification of disaster prone slopes, (2) Assessment of Potential Frequency of Road Closure Disaster (FRCDp) of slopes, (3) Disaster magnitude of slopes, (4) Preliminary preventive countermeasure planning and cost estimates, (5) Indicative feasibility assessment for preliminary countermeasures, and (6) Encoding of collected information to RSMS Database System. The features of the Inventory Survey are summarized as the estimation of the Potential Frequency of Road Closure Disasters per year (FRCDp), the Indicative Feasibility Assessment, and the evaluation by disaster type.

The basic design/development policies for the RSMS database system are a) To design/develop a compact database application system, b) To design/develop an easy-to-use system for the users, and c) To adopt a standard tool. Hence, the RSMS database application system was designed to have three components such as 1) Excel files for communicating data and information between the Central Office where the database server computer is located and the remote offices, 2) the Relational Database Management System, 3) A map display system for visual understandings of the stored information.

All Preliminary Inventory Survey data collected in the pilot study were stored in the database. The Detailed Inventory Survey data were stored in the database as the survey was being undertaken and the Excel files sent to the project office.

Inventory survey / RSMS database can provide risk level indicators for the evaluation of the effectiveness of slope disaster prevention projects and the setting of the next stage target level. Planning should be done utilizing the RSMS database through the processes of (1) Assessment of the risk level of RCD of a road section under current state, (2) Data collection of reference values for target-setting, (3) Target-setting for risk level indicators, (4) Prioritization of road sections for risk management, and (5) Direction to local offices for planning the disaster prevention projects and risk avoidance management system.

5 RESULTS OF PILOT INVENTORY SURVEY

Sixteen National Highway road sections in six (6) Regions were selected for the pilot PIS. Along the 332 km of road sections, 1,993 slopes were surveyed based on the PIS criteria. Results indicate that around 61% had a high risk level that required a DIS. The most dominant Disaster

Type was found out to be RS (41%), followed by SC (28%) and RC (16%).

DIS was conducted on 244 slopes on 11 road sections, in total length of 61 km, in four Regions, producing the annual loss, cost and benefit of each of the three alternative countermeasures for each slope, as well as the total annual loss (AL), potential intensity of annual loss (IALp), and the cost and annual benefit of countermeasures for each road section.

6 FEASIBILITY STUDY

Feasibility studies have been carried out for five sites selected as model studies. The feasibility study is composed of five tasks: Field Survey, Initial Environmental Examination (IEE), Social Survey, Countermeasure Design, and Feasibility Assessment.

For each of the study sites, based on the identified Disaster Type, outcomes of the Inventory Survey and results of the field investigation, preliminary design and cost estimates for a few optional countermeasures were carried out, and an optimal option from the engineering aspect was selected.

At this early stage, it is apparent that the viability of any of the countermeasures will be low, given that these interventions should have been done at the time that the road was constructed. The proposed projects are intended to mitigate/avoid the occurrence of sediment-related disasters on national highways and are thus not subject to the conduct of an Environmental Impact Assessment (EIA). As for the social impact, the proposed sites have no/minimal human activity and residents.

7 CONCLUSION AND RECOMMENDATIONS

This Study was carried out jointly by the JICA Study Team and the DPWH Counterpart Team, which periodically reported to, and were authorized by, the Technical Working Group and the Steering Committee.

The DPWH engineers acquired the skills needed to complete the Inventory Surveys properly and mastered the various kinds of skills needed for the work. The lack of geotechnical engineers with advanced knowledge of the technology for slope engineering is the only issue affecting the quality of the Inventory Surveys for the nationwide national highways. It has been proven that the DPWH organization functions adequately to carry out this kind of work. The pilot Inventory Survey was a simulation to illustrate how to execute the nationwide inventory surveys, and it demonstrated the potential capability of DPWH for the work in both the technological and institutional aspects.

To improve the situation for providing reliable traffic on the national highways, it is recommended that timely risk management be applied to the critical sections by the new methods developed in the Study It is estimated that it will require roughly two years to formulate a risk management program for road slope disasters on national highways nationwide, including preparatory seminars/workshops, inventory surveys, encoding to a database, and risk management planning.

The RSMS developed in this Study is an application to complement the two applications, PMS (Pavement Management System) and BMS (Bridge Management System). The establishment of the RSMS in close linkage with the PMS and the BMS will enable the formulation of a reasonable and balanced multi-year risk management program for road slopes along the national highways. The constant allocation of resources to the "Comprehensive Road Maintenance and Risk Management Program" is strongly recommended in order to gain control of RCDs on the national highways. Adequate budget support will ensure the success of the program.

One of the major targets in controlling RCDs is the reduction of recurrence. To reduce the recurrence of RCDs, the basic procedures for the design and construction methods shall be improved from the viewpoint of slope engineering. The introduction of advanced countermeasures to some key slopes is recommended to ensure the safe and smooth road traffic. Suitable technological development is very important to suitably treat and manage dangerous slopes.

The Study developed an inventory survey system for road slopes, named the RSMS. This may be only a part of the activities of DPWH to reform the work processes to provide road users with safe and smooth traffic. But the Study Team sincerely hopes that the RSMS would be utilized appropriately, coordinated with PMS and BMS to formulate systematic and reasonable multi-year programs that will contribute to the improvement of the traffic function on the national highways of the Philippines.

THE STUDY
ON
RISK MANAGEMENT FOR SEDIMENT-RELATED DISASTER
ON SELECTED NATIONAL HIGHWAYS
IN
THE REPUBLIC OF THE PHILIPPINES

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EXECUTIVE SUMMARY

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DEFINITION OF TERMS FOR RISK MANAGEMENT OF ROAD SLOPE DISASTERS (RSD)

Terms		Definitions
Disaster	:	A road slope failure, which could stop traffic flow and be dangerous to road users and inhabitants along the road.
Disturbance	:	Deformation of the slope and road structures and slope collapse which has not reached the road.
Visible Disturbance	:	Signs of potential disaster such as collapse, open cracks, depression, upheaval, muddy spring water on the road or slope.
Road Closure Disaster [RCD]	:	A disaster which causes closure of the whole or partial width of the road Deformations and collapses that do not close the road are not necessarily regarded as a RCD but just as a 'Disturbance'.
Loss	:	Monetary amount of damage caused by a disaster, specifically defined as the sum of the reopening cost, human lives lost, and detour cost.
Risk	:	The total damage characterized by the potential frequency and magnitude of the disaster. Annual total loss is an expression of the risk. The risk is distinguished from the hazard, which could be defined, in case of this Study, as the overt danger to the road and road users.
Frequency of Road Closure Disasters per Year [FRCD]	:	The number or RCD occurrences per year for a slope
Intensity of Road Closure Disasters of Road Section [IRCD]		Average RCD occurrences per unit length per year for a road section, *i.e.* the total FRCD's for the road section divided by its length

ACRONYMS/ABBREVIATIONS

AADT	Annual Average Daily Traffic
ADB	Asian Development Bank
ADB-PMO	Asian Development Bank- Project Management Office
AMMS	Administrative and Manpower Management Service
ASEC	Assistant Secretary
AVOC	Average Vehicle Operation Cost
AWP	Annual Work Programs
BCGS	Bureau of Coast and Geodetic Survey
BCR	Benefit Cost Ratio
BIIPs	Business Improvement Implementation Projects
BMS	Bridge Management System
BOC	Bureau of Construction
BOD	Bureau of Design
BOE	Bureau of Equipment
BOM	Bureau of Maintenance
BRS	Bureau of Research and Standards
CAR	Cordillera Administrative Region
CARBDP-PMO	Cotabato-Agusan River Basin Development Project-Project Management Office
CCE	Coefficient of Countermeasure Effectiveness for FRCDp
CDPCD	(DPWH'S) Calamities and Disaster Preparedness Control Plan
CF	Calamity Fund
CFMS	Comptrollership & Financial Management Service
CMS	Contract Management System
DAO	DENR's Administrative Order
DBM	Department of Budget and Management
DBMS	Data Base Management System
DCB	District/City Disaster Coordinating Bodies
DCC	Disaster Coordinating Council
DE	District Engineer (Head of District Engineering Office)
DENR	Department of Environment and Natural Resources
DEO	District Engineering Office
DO	Department Order
DND	Department of National Defense
DPD-PS	Development Planning Division-Planning Service

DPMP	Disaster Preparedness Management Plan
DPWH	Department of Public Works and Highways
DIS	Detailed Inventory Survey
ECC	Environmental Compliance Certificate
EGGA	the Engineering, Geological and Geohazard Assessment (EGGA)
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMK	Equivalent Maintenance Kilometer
ENPV	Economic Net Present Value
EO	Executive Order
EPS	Expandable Polystyrene
ESSO	Environment & Social Safeguard Office
ExIS	Executive Information System
FAP	Foreign Assisted Projects
FCSEC - PMO	Flood Control and Sabo Engineering Center- Project Management Office
FRCD	Frequency of Road Closure Disaster
FRCDa	Actual Frequency of Road Closure Disaster per year
FRCDbc	Frequency of Road Closure Disaster per year before Countermeasure Period
FRCDp	Potential Frequency of Road Closure Disaster per year
FRCDpwc	Potential Frequency of Road Closure Disaster with Countermeasure per year
GAA	General Appropriations Act
GIS	Geographic Information System
GOP	Government of the Republic of the Philippines
HMP	Highway Management Project (IBRD-financed)
I/A	Implementation Agreement
IBRD	International Bank for Reconstruction and Development
IBRD-PMO	International Bank for Reconstruction and Development-PMO
IRF	Immediate Response Fund (of DPWH's Regional Office)
IROW	Infrastructure Right-of-Way
IRR	Implementing Rules and Regulations
IPRSD	Infrastructure Planning Research and Statistics Division
LAN	Local Area Network
LGU	Local Government Unit
LRS	Locational Reference System
LRP	Locational Reference Point
LLO	Legislative Liaison Office

LTPBMC	Long Term Performance-Based Maintenance Contracts
LWUA	Local Water Utilities Administration
MGB	Mines and Geosciences Bureau
MBA	Maintenance by Administration
MBC	Maintenance by Contract
MDG	Millennium Development Goals
MIS	Monitoring and Information Service
MVUC	Motor Vehicle User's Charge
MWP	Multi-Year Work Programs
MWSS	Metropolitan Waterworks Sewerage System
MYPS	Multi-Year Programming and Scheduling
NAMRIA	National Mapping & Resource Information Authority
NCA	Notice of Cash Allocation
NCR	National Capital Region
NDRB	Natural Disaster Reduction Branch
NDCC	National Disaster Coordinating Council
NDCB	National Disaster Coordinating Body of DPWH
NEDA	National Economic Development Authority
NFC	Notice of Funding Ceiling
NGA	National Government Agency
NRIMP	National Roads Improvement and Management Program
NSO	National Statistics Office
OP	Office of the President
OCC	Opportunity Cost of Capital
OCD	Office of Civil Defense under Department of National Defense
PAGASA	Philippine Atmospheric, Geophysical & Astronomical Services Administration
PD	Presidential Degree
PDCA	Plan Do Check Action
PDD	Planning and Design Division (DPWH Regional Office)
PD-PS	Programming Division-Planning Service
PED-PS	Project Evaluation Division-Planning Service
PHIVOLCS	Philippine Institute of Volcanology & Seismology
PJHL-PMO	Philippine-Japan Highway Loan-PMO
PIS	Preliminary Inventory Survey
PMO	Project Management Office
PMS	Pavement Management System

PS	Planning Service
QRF	Quick Response Found (of DPWH'^s Central Office)
RA	Republic Act
RB	Road Board
RBIA	Road and Bridge Information Applications
RBS	Road Board Secretariat
RCD	Road Closure Disaster
RDCB	(DPWH's) Regional Disaster Coordinating Bodies
RDBMS	Relational Database Management System
RDCC	Regional Disaster Coordinating Council
RES	Regional Equipment Services
RMMS	Routine Maintenance Management System
RO	Regional Office
ROW	Right of Way
RPO	Road Program Office
RIS	Road Information System
RSD	Road Slope Disaster
RSMS	Road Slope Management System
RTIA	Road Traffic Information Application
RIMSS	Road Information Management Support System
R/R	Request for Release
RRR	Risk Reduction Ratio
SARO	Special Allotment Release Order
SONA	State of the Nation Address
SOPs	Standard Operation Procedures
SARO	Special Allotment Release Order
SQL	Structural Query Language
SRSaF	Special Road Safety Fund
SRSF	Special Road Support Fund
STRIDE	(PAGASA's team of) Special Tropical Cyclone Reconnaissance Information Dissemination and Damage Evaluation
TARAS	Traffic Accident Reporting and Analysis System
URPO-PMO	Urban Roads Project Office-Project Management Office
VOC	Vehicle Operation Cost
XSps	Cross-Sectional Positions
WAN	Wide Area Network

CHAPTER 1 INTRODUCTION

1.1 Background of Study

With the development of the road network of over 200,000 km in total length including 30,000 km of national highways, road slope disasters along the road have provoked wide public attention. These road slope disasters frequently destroy or block roads, particularly during the rainy season, resulted from such natural conditions as steep topography, fragile geology, heavy rainfall and frequent earthquakes.

The Department of Public Works and Highways (DPWH) in the Republic of the Philippines is responding to the difficult issue with available resources and expertise as well as with the assistance of international funding agencies. However, these efforts have been insufficient because of limited budgets, inadequate management systems and inappropriate technology to prevent or mitigate road slope disasters.

In response to an official request from the Government of the Republic of the Philippines (GOP) to formulate a systematic procedure for road slope management, JICA discussed with DPWH in September, 2004 and agreed upon the Scope of Work for the Study on Risk Management for Sediment-related Disaster on Selected National Highways in The Republic of The Philippines

1.2 Objectives of Study

The ultimate goals of road slope management are the improvement of traffic function and to increase the level of safety on national highways against road slope disasters. To achieve these goals, the objectives of the Study were set up as follows:

a) Development of a road slope inventory survey system for national highways
b) Creation of a road slope database system enabled to continuously update the data
c) Formulation of a systematic plan to execute the disaster management, taking into account the countermeasures to mitigate and prevent road slope disasters
d) Capability enhancement of the DPWH engineers in the assessment and management of road slope disasters on the national highways through the transfer of technology and skills

1.3 Study Areas

There are 332 km of road sections selected for the preliminary inventory survey (PIS), of which 61 km have been prioritized, based on the PIS results, for implementation of pilot detailed inventory surveys (DIS). Further, five sites for the model feasibility study on the respective countermeasure have been selected.

1.4 Process of the Study

The Study has been implemented in two phases from 14th March 2006 to June 2007, as shown in Figure 1.1.

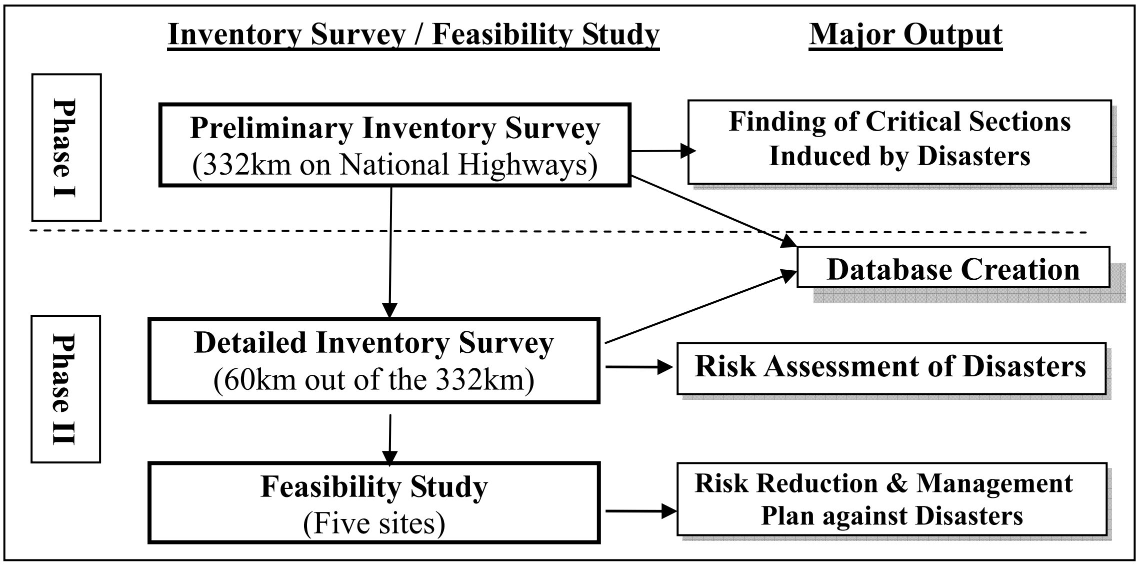


Figure 1.1 Outline of the Study

1.5 Organization for the Study

In accordance with the Minutes of Meeting on the Scope of Work of the Study dated 23rd September, 2004, the implementation organization for the Study is composed of the JICA Philippine Office as the client, the DPWH as the GOP counterpart, and the JICA Study Team. The Study was carried out under a three-layer management structure consisting of the Steering Committee (S/C), the Technical Working Group (TWG) and the JICA Study Team in joint cooperation with the DPWH Counterpart Team.

1.6 Technical Transfer

A joint work between the JICA Study Team and its DPWH counterpart, as stipulated in the

Implementation Agreement between JICA and DPWH for the Study, the activities to carry out the Study, as well as to master the results 0f the Study themselves are the focus of the technical transfer from the Study Team to DPWH. The technical transfer during the Study period was promoted in three ways, including;

１) Joint work between the JICA Study Team and DPWH personnel,
２) On-the-job training for DPWH personnel, and
３) Seminars/Workshops for DPWH personnel.

Actually, most of both the preliminary and detailed Inventory Surveys of the slopes along the selected routes/sections of the national highways were executed by DEO engineers with the assistance of the JICA Study Team and/or DPWH Counterpart Team members as on-the-job training. During the period of the Study, four Seminars/Workshops were held to disseminate the methodology of road slope management.

CHAPTER 2 OVERVIEW OF SLOPE DISASTERS ON NATIONAL HIGHWAYS

2.1 Natural Conditions Related to Slope Disasters

2.1.1 Topography and Geology

The islands of the Philippines emerged from the sea due to the activity of the Philippines Sea Plate in the late Cretaceous period. This plate activity continues today. The basement complex of the islands is formed by dynamo-metamorphic rocks such as amphibolites, mica-schist, and phyllites. Most of the islands on the basement complex are formed by soft sedimentary rocks. At the same time, the volcanic rocks such as andesites, basalt and tuffs had been produced by repeated volcanic activity.

These rocks are sheared and fractured in many places by the Philippine Fault and its related faults that pass from NNW to SSE through the center of the Philippine islands. Rocks in the mountainous areas encountering faults in many places are often fractured. This is one of the characteristics of base rocks of the Philippines that result in collapses and slides.

2.1.2 Climate

The climate of the Philippines features uniform temperature, high humidity and much rainfall in the tropical monsoon zone that arise mainly due to the maritime exposure of the country. Climate in the Philippines is classified into four types as given below:

(1) Dry/Rainy: Western Luzon, Mindoro and Palawan
(2) No Dry Season with a very pronounced maximum rainfall from November to January: Eastern Mindanao and Southeastern Luzon
(3) Obscure Dry/Rainy: Northern-Central of Luzon
(4) Rainy throughout the year: Easternmost Luzon and Central Mindanao

Annual average rainfall varies in the regions from 960 mm to 4,600 mm, with half the rain brought about by typhoons, a major cause of road disasters.

2.2 Slope Disaster Types Occurring on National Highways

2.2.1 General

The Study Team, together with the Counterpart Team, classified road slope disasters on the national highways in the Philippines into seven (7) types, as schematically shown in Figure 2.1, taking into consideration the failure mechanism and countermeasure options for each disaster type.

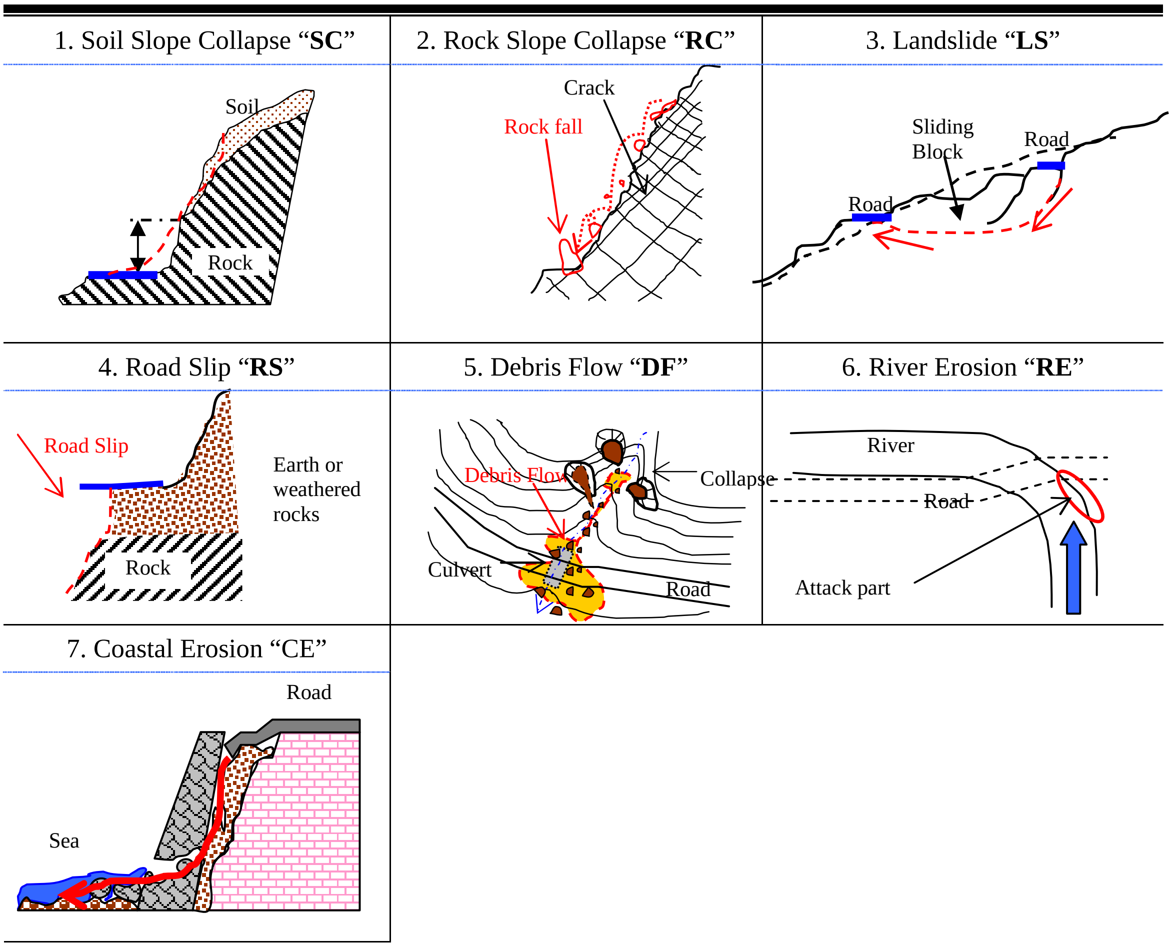


Figure 2.1 Schematic Illustrations of Seven Disaster Types

2.2.2 Explanation of Disaster Types

(1) Soil Collapse (SC)

Rapid soil slope failures occur in high cut or natural slopes with gradients of over 50 degrees and are triggered mostly by heavy rainfall. Material is generally residual soil produced by weathering of rocks or detritus soils hanging in steep slopes. Generally, the volume involved in the collapse is rather small, ranging from dozens to several hundreds of cubic meters.

(2) Rock Slope Collapse (RC)

Rock slope collapses occur in hard rock slopes with gradients over 50 degrees. Collapse modes are free fall or rolling down of the rock mass, which is usually below dozens of cubic meters. In natural hard rock slopes large scale failures occur, through such mechanisms as large scale planar slide, spread, wedge slide and toppling. But in this classification, these large scale slope failures are included in the "Landslide Type", because countermeasures to treat large scale rock mass failures are similar to the measures for large landslides.

(3) Landslide (LS)

Generally, "landslides" refer to all types of slope failures. In this classification, "Landslide" (LS) is defined as a large mass movement including large mass soil slide, rock wedge block slide, and rock slope toppling or spreading.

(4) Road Slip (RS)

"Road Slip" is a colloquial term commonly used by DPWH road engineers to mean a slope failure or deformation of the shoulder of roads in hilly areas. Road slips occur in many places on national highways because of the collapse of the valley-side slope, scouring of slopes induced by leakage of water from destroyed drainages, and settlement of the road embankments.

(5) Debris Flow (DF)

Debris flow is the rapid flow of boulders, gravel, sand, silt, clay, and trees mixed with a large quantity of water that is mainly generated by slope collapse under heavy rainfall. It flows rapidly down on the riverbed with slopes of over 20-degrees, and stops to deposit the debris in the riverbed where the gradient is less than 10 degrees.

(6) River Erosion

River erosion is a slope failure type which occurs mainly in embankments, and rarely in natural slopes along rivers. Slopes along rivers are affected by successive river erosion and scouring by floods, resulting in slope failures.

(7) Coastal Erosion

Coastal erosion is a slope failure type along the coastline induced by tidal erosion. It occurs mainly in embankments, and rarely in natural slopes along the coast.

2.3 Damage by Road Slope Disasters on National Highways

In this study, a questionnaire survey was made on the occurrence of RCDs on national highways in 2004 and 2005. The total road length that has risks of road closure disaster is 1,774 km out of 29,005 km of national highways. In 2004 and 2005, RCDs occurred 2,969 and 2,447 times, respectively, or an average of 2,708. Losses induced by RCDs were estimated at approximately PHP 2,600 million as shown in Table 2.1.

Table 2.1 Annual Average Road Closure Disasters (based on 2004 & 2005 data)

Region	Total Road Length	Road Length with RCD Risk	Annual Nos. of RCDs	Actual Intensity of RCD	Annual Losses
Unit	km	km	nos. of RCDs per year	nos. of RCDs per (year*km)	million pesos per year
Acronym	**TRL**	**RLwRCD**	**ANRCD**	**IRCDa**	**AL**
Expression				**ANRCD/ RLwRCD**	
CAR	1,844	238	981	4.13	1,171
NCR	1,014	5	1	0.20	0
I	1,609	82	41	0.50	25
II	1,753	208	193	0.93	210
III	1,989	260	235	0.90	367
IV-A	2,404	116	62	0.53	47
IV-B	2,172	157	326	2.08	197
V	2,196	30	95	3.19	77
VI	2,880	93	134	1.45	69
VII	1,960	114	153	1.34	66
VIII	2,332	88	86	0.97	63
IX	1,140	103	36	0.35	17
X	1,604	90	57	0.63	39
XI	1,446	102	84	0.82	78
XII	1,304	30	88	2.92	86
XIII	1,357	59	138	2.33	115
Grand Total	**29,005**	**1,774**	**2,708**		**2,627**
Average				**1.45**	
				Rounded figure to two decimal	

RCD: Road Closure Disaster

2.4 Existing Countermeasures against Road Slope Disasters

2.4.1 Types of Existing Countermeasures

Various kinds of countermeasures for road slope protection on national highways have been implemented for the construction of new roads and the rehabilitation of existing ones. These countermeasures are categorized according to the disaster types for which they are used, as shown in Table 2.2.

2.4.2 Technical Improvement in Countermeasures

The rapid development of the road network under adverse natural conditions and limited budgets has resulted in the need for more countermeasures on road slopes for the following reasons:

- Existence of unforeseeable defects in the slopes in the construction stage

- Inappropriate design or construction in the construction stage
- Absence of suitable repair or rehabilitation works in the maintenance stage.

Table 2.2 Existing Countermeasures to Prevent Slope Disasters

Types of Road Slope Disasters	Types of Existing Countermeasures
1. Soil Slope Collapse (SC)	1.1 Cutting
	1.2 Surface drainage channels (masonry)
	1.3 Retaining walls (gabions, masonry and concrete)
	1.4 Vegetation
2. Rock Slope Collapse (RC)	2.1 Catch wall (gabions, masonry and concrete)
	2.2 Catch fence
	2.3 Mortar shotcrete
	2.4 Rock shed
3. Landslide (LS)	3.1 Retaining wall (gabions, masonry and concrete)
	3.2 Vegetation
4. Road Slip (RS)	4.1 Surface drainage channel (masonry)
	4.2 Retaining wall (gabions and masonry)
	4.3 Reinforced Soil embankment
5. Debris Flow (DF)	5.1 Sabo dam (masonry)
6. River Erosion (RE)	6.1 Revetments (gabions, masonry and concrete)
	6.2 Groins
7. Coastal Erosion (CE)	7.1 Concrete retaining wall
	7. 2 Grouted Rip Rap
	7.3 Wave absorbing works

Major matters to be improved in the design and construction of countermeasure for slopes are described below.

(1) Drainage Work

Surface drainage is often poor or insufficient to cope with the concentration of surface flow on roads during heavy rainfall. This has been a major cause of the occurrence of erosion or slope failure on the valley side slope of the road, specifically soil collapse, landslides and road slips triggered mostly by water flow caused by heavy rainfall and subsequent erosion resulted as a result of inappropriate drainage design.

To mitigate the road slope disasters resulting from water flow and erosion, the following technical improvements are recommended to provide a proper and effective drainage system:

- Proper drainage systems that prevent water from flowing into disaster-prone areas should be constructed. If possible, surface water should be guided to locations outside the disaster-prone areas.
- The kind and size of drainage facilities should be selected properly using hydraulic calculation.

(2) Cutting Work

Though there are few cut slopes higher than 20 m, in some sections of the national highways collapses occur repeatedly, showing that the design methods used were inappropriate: *ex.* too steep a gradient to keep the slope stable, no berms (bench/ terrace) for slopes over 10 m high; and no drainage system or protection measures.

Cut slopes are highly susceptible to different types of road slope disasters. Design of cut slopes should be made by empirical engineering review, based on the conditions of the past disasters, such as (a) soils and geological formations, (b) design and condition of execution of works, and (c) stability conditions, and proper engineering judgments on the site conditions.

(3) Foundation for Structures

The depth of the foundations for the structures often does not reach a stable layer, especially in wall structures constructed in steep valley side slopes, river revetments or retaining walls along coastlines. This has caused the collapse of many structures.

(4) Knowledge and Technology for Large-scale Landslide

In some sections where large-scale landslides are occurring, there are no suitable design or countermeasure works implemented. Placing fill on the landslide foot is a basic countermeasure to mitigate the movement of a large landslide. Earthworks should be applied more practically, taking into consideration the mechanism of slope failure at each site. The effective technologies recognized internationally for large landslide control can be applied.

(5) Introduction of New Technology

It is sometimes difficult to prevent road slope disasters in the areas of adverse natural conditions, such as steep topography, fragile geology, etc. by applying common countermeasures such as gabions or concrete walls. Advanced technologies, which are already applied internationally for road slope protection, shall be introduced and implemented by the DPWH in a positive and consistent manner.

(6) Overall Plan for the Prevention of Road Slope Disasters in the Maintenance

Stage

Road maintenance practice at present is limited to the routine maintenance. Slope disaster preventive works, particularly required in the sections with critical slopes, are not sufficient, but rehabilitation efforts have been limited to the reopening of the closed road, resulting in the recurrence of the slope disasters and the increase of maintenance costs. An overall policy to manage the potential disasters sites, particularly of large-scale landslides, soil collapses and road slips, should be formulated to allow countermeasures to attain their purpose over a long period of time, preventing the decrease in slope stability and reducing repeated works.

CHAPTER 3 ACTIVITIES FOR ROAD SLOPE MANAGEMENT IN DPWH

3.1 General

The ongoing "Government Rationalization Program" has resulted in a number of new proposals for restructuring the DPWH. The possible actions regarding the functions/programs/activities/ projects of a Department/Agency include (a) scaling down; (b) phasing out; (c) abolition; and (d) strengthening.

3.2 The Organizational Structure of DPWH

The proposed structure of DPWH has been completed together with consultation within and external to DPWH.

Under the said structure, the Planning Service provides technical services relating to public works and highways infrastructure, planning, programming and project development. It also provides technical assistance and support; and maintains close coordination with other offices/agencies on matters relating to public works and highways, planning, programming and project development. The Service handles the Department-wide Road and Bridge Information Applications (RBIA), Pavement Management System (PMS), Bridge Management System (BMS) and Multi-Year Programming and Scheduling (MYPS) applications.

The Bureau of Maintenance (BOM) is primarily tasked with the maintenance of the nation's infrastructures and is engaged in the continuous upgrading of the technical skill of its personnel. It conducts field inspections to effectively monitor maintenance activities of the district/city engineering offices.

3.3 Implementation System for Road Maintenance and Disaster Management

3.3.1 Legislation on Disaster Management

The primary legislation on disaster management in the Philippines is Presidential Decree 1566 issued of 11 June 1978 – Strengthening the Philippine Disaster Control, Capability and Establishing a National Program on Community Disaster Preparedness. The major provisions of the law are (1) Policy on self-reliance among local officials and their constituencies in preparing for, responding to, and recovering from disasters or emergencies, (2) Organization of disaster coordinating councils from the national (NDCC) to the municipal (LDCCs) levels and statement of their duties and responsibilities, (3) Preparation of the National Calamities and Disaster Preparedness Plan (NCDPP) by the Office of Civil Defense (OCD) and the implementation plans by the NDCC member agencies and LDCCs, (4) Conducting of periodic drills and exercises by concerned agencies and LDCCs, and (5) Authority for government units to program their funds for disaster preparedness activities in addition to the 2% calamity fund.

3.3.2 National Disaster Coordinating Council (NDCC)

The NDCC is the primary body responsible for various facets of responding to national disasters. It acts as the top coordinator of all disaster management and the highest allocator of resources in the country to support the efforts of the lower Disaster Coordinating Council (DCC) levels (regional, provincial and city/municipal). In the discharge of its functions, it utilizes the facilities and services of the OCD of the Department of National Defense as its operating arm.

3.3.3 Other Agencies Concerned with Disasters

(1) Mines and Geosciences Bureau (MGB) under the Department of Environment and Natural Resources (DENR)

The DENR-MGB produces geohazard maps for selected urbanized and urbanizing areas. The geohazard maps provide information on potential areas of slope failures, liquefaction, and subsidence.

(2) Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) under the Department of Science and Technology (DOST)

For hazard mapping, PAGASA gathers basic information and observation data on meteorological and hydrological hazards, and processes, validates and analyzes the information to locate the hazard, using historical records to identify critical hazard zones. The results of the analyses are usually presented in the form of maps that show the type and degree of hazard in a given geographical location. In vulnerability analysis, it is possible to identify geographically, with reasonable accuracy, those elements such as settlements, communities and assets that are more particularly susceptible to damage or destruction from a hazard. The results of vulnerability analysis are also presented in the form of maps.

(3) Philippine National Police

In cases where fatalities or injuries occur due to RCDs or other disasters, the police are called to conduct an investigation of the incident to determine culpability (human or natural). They prepare an appropriate police report and the DEO secures a copy, which is submitted to the DPWH Regional and the Central Offices for input into the TARAS.

3.3.4 Disaster Management System in DPWH

(1) Road Maintenance System

The existing road maintenance management system ignores the areas peripheral to the road pavement. This lack of attention affects road conditions and subsequently road maintenance requirements.

(2) Emergency Management System

The DPWH has promulgated its Calamities and Disaster Preparedness Control Plan (CDPCP) and Standard Operating Procedures (SOPs) in 1988. The plan is intended to anticipate all possible contingencies making use of available DPWH resources and also tap the assistance of the private sector particularly those in the construction industry, to enhance capabilities on disaster preparedness and control.

The DPWH's NDCB is the implementing arm of the department in exercising direction and control overall emergency operations nationwide and maintaining close coordination with the NDCC through the OCD. However, at present, these Disaster Coordinating Bodies seem to no longer formally exist.

(3) Information System for Road Maintenance

The absence of a "Road Slope Disaster Management System" is evident from the existing RBIA where information on road condition is limited to roughness and visual observations (pavement condition).

The existing practice is for information on RCDs to be reported directly by the DEO's Maintenance Engineer to the Bureau of Maintenance (BOM) for relay to the NDCC for dissemination to the public. The agreed reporting frequency between the BOM and the District's Maintenance Engineer is every 4-6 hours until such time that the condition has normalized. The reports include information on road closures, any injuries or deaths caused and other pertinent information needed. During and after each disastrous event such as typhoons, heavy rains and earthquakes, the DEO dispatches its road maintenance teams to sites historically identified as potential disaster sites. In sections where the risk is considered high, the DEO may already position earth-moving equipment to insure that the road is immediately reopened when the situation stabilizes.

(4) Organization at the DEO Level

The implementation of the DEOs road maintenance program is undertaken by maintenance work teams led by a "kapatas or foreman" who is responsible for supervising the team's activities in the field. Their specific activities for a specified period are managed by the DEOs area engineers for the specified road sections, while overall supervision of the DEO's maintenance activities is under the Maintenance Engineer.

3.4 Budgetary Situation in Road Maintenance

3.4.1 Regular Funding Sources for Road Maintenance

Currently, funding for road maintenance activities is wholly sourced from the 151 Special Road Support Fund programmed by the Road Program Office (RPO), from the proceeds of the Motor Vehicle User Charges (MVUC). From 2002 to June 2006, DPWH had withdrawn the accumulated amount of P17.09 B from the said funds for road maintenance.

As of June 2006, the unspent total balance from MVUC collections has reached P11.82 B of which P7.46 billion are intended for national road maintenance.

The use of Fund 151 is directly under the purview of DPWH through RPO and are allocated based on the Annual Work Program and Multi-year Work Program prepared. This fund is presently the only source for routine and preventive road maintenance, though the Department of Budget and Management (DBM) has withheld the utilization of the full amount of the available revenues from MVUC.

3.4.2 Other Funding Sources for Road Maintenance

When the cost of the immediate response is within the financial resources of the DEO, the DEO undertakes the activity right away using its road maintenance budget.

Each MBC contract allocates 15% of the total amount to the emergency funds which can be utilized at the discretion of the District/City Engineer. When events such as typhoons and earthquakes cause substantial damage to the road infrastructure beyond the capacity of the DEO's resources, the DEO reports the event to the DPWH Regional and Central offices for the purpose of securing the Immediate Response Fund (IRF) and the Quick Response Fund (QRF), respectively, to restore the infrastructure.

The NDCC administers the national calamity fund under the General Appropriations Act. The fund is used for aid, relief and rehabilitation services to areas affected by man-made and natural calamities and repair and reconstruction of permanent structures. However, certainty that funding will be provided is low due to the limited budget available.

Other possible funding sources used for reopening cost include ODAs that are made available by various donor countries to assist the national government in times of disasters.

3.4.3 Road Maintenance Expenditures at the DEO Level

The actual road maintenance expenditure differed by DEO, depending on the maintenance budget allotted to the specific DEO. The actual average maintenance expenditures from 2001-2005 and 2006 (estimated) are given as PHP 14 to 25 Million. The expenditures declined from 2001 to 2005. The proposed 2006 average maintenance expenditure is lower than 2001-2004 levels.

3.5 Proposed 2006–2010 DPWH Medium-Term Public Investment Program

The DPWH, in its medium term investment program, has proposed a total of P236.76 billion for 2006-2010. Of this amount, P146.52 billion is to be funded from ODA of which P70.51 billion is for on-going projects and P13.52 billion is intended to fund the cost over-runs of completed and on-going projects. Thus, only P76.01 billion or 51.9% is actually intended to finance proposed (new) projects. Of the total amount allocated, only P90.24 billion or 38.1% is to be funded out of local funds. This shows the continuing dependence of the national government on ODA to fund the infrastructure program.

NRIMP 2 is also intended to continue NRIMP 1 activities in terms of the implementation of the Long Term Performance-Based Maintenance Contracts (LTPBMC) for asset preservation, possibly exploring other possible modalities.

3.6 Issues in Road Maintenance

The current system for the conduct of road routine maintenance activities excludes road slopes, which are therefore not included in the estimation of the EMK. Thus, an important issue would be how the cost of road slope maintenance activities could be included/integrated into the EMK. The second issue is how road slope-related maintenance activities would be funded, given that currently, the financial resources allocated by the national government through the GAA and MVUC are insufficient. Even the release of road maintenance funds out of the MVUC has been very erratic and less than the Road Board-approved amount. This has resulted in the continued deterioration of the national road system. The third issue is who will undertake the road-slope related maintenance activities given that the DPWH DEO does not have even the optimum manpower to undertake routine maintenance. While the implementation of the "rationalization plan" may improve DEO's manpower resources, this may only be in keeping with the targeted 90%/ 10% MBC-MBA allocation. While DPWH is still piloting the LTPBMC modality, the results are still being evaluated and new modalities are being proposed. This may further delay the privatization of the DPWH's road maintenance activities.

CHAPTER 4 DEVELOPMENT OF ROAD SLOPE MANAGEMENT SYSTEM

4.1 General

4.1.1 Necessity of RSMS

The measures to prevent and mitigate the RCDs have not been sufficient due to the limited budget allocated and the lack of an effective policy to cope with RCDs. This situation can be improved through the implementation of a systematic and effective management by DPWH. Practical and successful risk management regarding RCDs will improve the traffic function and safety of national highways.

4.1.2 Outline of RSMS Component

RSMS is composed of three major components including (1) Inventory Survey of road slopes on national highways, (2) Database System for road slopes on national highways, and (3) Risk management planning.

To support the implementation of the three major components of RSMS, the Technical "Guides" have been prepared as Guide I Risk Management Planning, Guide II Inventory Survey, and Guide III Road Slope Protection.

(1) Inventory Survey

The Inventory Survey is designed to be implemented by completing five types of templates prepared for two stages: the Preliminary Inventory Survey (PIS) and the Detailed Inventory Survey (DIS). The Preliminary Inventory Survey is undertaken to identify disaster-prone slopes and assess the disaster frequency of the slopes. The Detailed Inventory Survey is carried out for selected critical slopes. In this stage, detailed slope observations, countermeasure planning and indicative feasibility assessments are undertaken and all information collected is encoded in the RSMS Database.

(2) RSMS Database Formulation

The RSMS database has such functions as (a) Import and export function between inventory data sheets and the database, (b) Formulation of the road slope inventory table, and (c) Map display function of RSMS.

(3) Risk Management Planning

Risk levels and feasibility indicators, which are obtained from the processed Inventory Surveys (IS)/RSMS database, are used for risk management planning. Risk avoidance measures such as early warning and traffic regulation systems are important components of risk management for RCDs. This should be undertaken according to DPWH's Calamities and Disaster Preparedness Control Plan (CDPCD) and Standard Operation Procedures (SOPs). The RSMS database and risk management policy should be used for the formulation of new, and revision of existing, risk avoidance management plans and operating procedures for specific road sections.

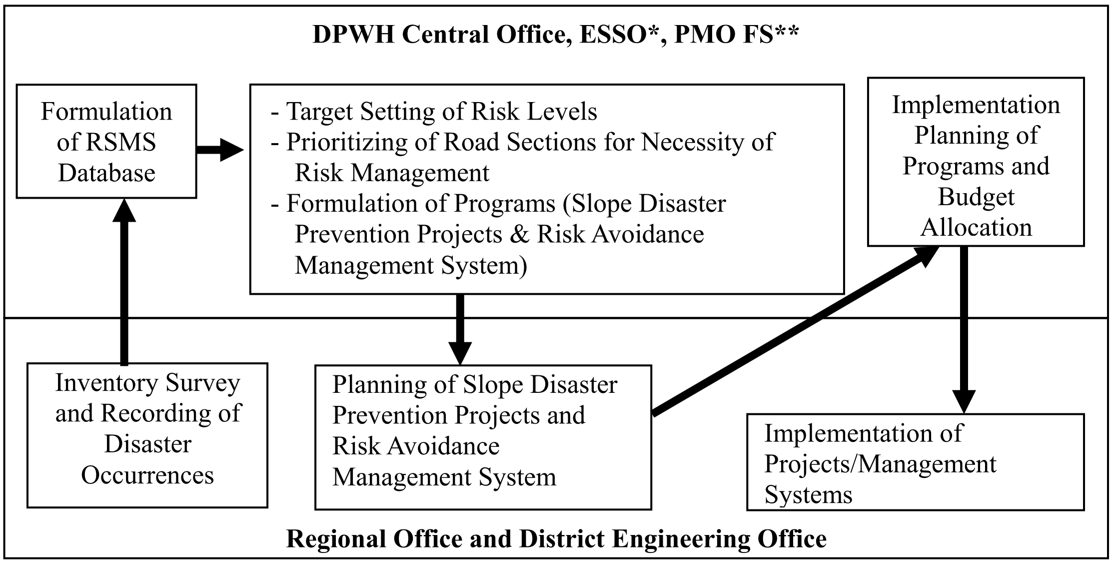
4.2 Implementation System for RSMS

4.2.1 PDCA Cycle for RSMS

The Road Slope Management System (RSMS) will be implemented using the so-called PDCA Cycle. The PDCA cycle for the RSMS starts from Inventory Survey (Check). Update of the inventory data and amendment of risk management procedure on RCDs follow it, if necessary (Action). Risk Management Planning is undertaken (Plan), and projects are implemented thereafter (Do).

4.2.2 Implementation System of RSMS and DPWH Unit Responsible

The work flow and responsible organization for risk management planning is shown in Figure 4.1.



ESSO: Environment & Social Safeguard Office

PMO FS: Project Management Office Feasibility Study

Figure 4.1 Implementation Systems for Road Slope Management

The Planning Service (PS) is the lead coordination center for the RSMS database and risk management planning. Bureau of Maintenance (BOM) coordinates the planning and implementation of the Risk Avoidance Management System as is the current practice. The planning units of the Regional Office (RO) and DEO serve as the focal points for the inventory surveys and risk management planning, while the maintenance units coordinate the planning and implementation of the Risk Avoidance Management System and routine maintenance rehabilitation works as is the current practice.

4.3 Inventory Survey Method

4.3.1 Purpose of the Inventory Survey

The general purpose of the Inventory Survey is to collect information regarding road slopes on national highways for proper and practical risk management. Specific purposes of the Inventory Survey are (1) Identification of disaster prone slopes, (2) Assessment of Potential Frequency of Road Closure Disaster per year (FRCDp), (3) Disaster magnitude of slopes, (4) Preliminary preventive countermeasure planning and cost estimates for slopes, (5) Indicative feasibility assessment for preliminary countermeasures, and (6) Encoding of collected information to RSMS Database System.

4.3.2 Flow and Major Output of Inventory Survey

The inventory survey is composed of a Preliminary Inventory Survey (PIS) and a Detailed Inventory Survey (DIS). The survey is carried out by filling out six types of Inventory Formats; *i.e.* (1) PIS; Screening of survey slopes (sheet 1), (2) PIS; Disaster frequency assessment and selection of slope for DIS (sheet 2), (3) DIS; Detailed Observation (Sheet 3), (4) DIS; Countermeasure planning and cost estimates (sheet 4), (5) DIS; Indicative Feasibility Assessment (sheet 5), and (6) Disaster Record (sheet 6). The major outputs are (1) Location and disaster type of the slope, (2) Actual Frequency of RCDs per year (FRCDa), Potential Frequency of RCDs per year (FRCDp), and necessity of DIS, (3) Detailed observation of the slope, (4) Countermeasure plan and cost estimate, and (5) Disaster magnitude and feasibility indicators.

4.3.3 Features of the Inventory Survey

(1) Estimation of Potential Frequency of Road Closure Disaster (FRCDp)

Since the focus of the inventory survey is on the evaluation of the hazard conditions that could cause slope disasters, assessment of hazard conditions shall be quantitative. The concept of "Frequency of Road Closure Disaster per year (FRCD)" is introduced to quantify the hazard condition of the road slopes. FRCDp is the major indicator to estimate the hazard level, risk level and feasibility indicators throughout the inventory survey.

(2) Indicative Feasibility Assessment

The Indicative Feasibility Assessment is the final result of the Inventory Survey. By introducing the concept of FRCDp, it is possible for economic loss and countermeasure effectiveness to be estimated. This provides important information for target setting of risk level and economically effective policy-making for road slope management.

(3) Evaluation by Disaster Type

As previously mentioned, slope disasters along the national highways in the Philippines are classified into seven types. Differing inventory formats are designed for those disaster types, taking into consideration their individual characteristics of failure mode and failure mechanisms.

4.4 Development of Road Slope Database System in RSMS

4.4.1 Design Concept

The basic design/development policies for RSMS are a) To design/develop a compact database application system, b) To design/develop an easy-to-use system for the users, and c) To adopt a standard tool. Hence, the RSMS database application system was designed to have three components comprising 1) Excel files for communicating data and information between the Central Office and the remote offices, 2) The relational database management system, which is the core of RSMS's database application system, and 3) A map display system for visual understandings of the stored information.

4.4.2 Program Design and Development

The software and hardware, including IBM X206 Server PC with additional memory and disk storage, Microsoft Windows Server 2003 with 5 CALs (client access licenses) as the server OS, and Microsoft SQL Server 2005 Standard Edition with 5 CALs (client access licenses) as the Relational Database System, were procured to develop the application system.

When a user retrieves all the data from the database, a resulting form is displayed. In addition, the user can filter the data by issuing a query. As elements of the query, the user can use the items such as Region Name, District Engineering Office Name, Road Name, Disaster Type, and Survey Year. The list of the data retrieved can be exported into Excel file easily. A pie chart or bar chart can be drawn and exported into the same Excel file. The survey point data can be imported into the GIS map easily. Their locations are displayed on the map so that the user can determine the geographic distribution of the survey points. The user can access the survey Excel files on the monitor for the GIS application.

4.4.3 Database Creation for Selected National Highways

All Preliminary Inventory Survey (PIS) data collected in the pilot study were stored in the database. The Detailed Inventory Survey (DIS) data were stored in the database as the survey was being undertaken and the Excel files sent to the project office.

4.4.4 Deployment Plan

(1) Integration with RBIA

The integration of the RSMS database into the RBIA database application system is one choice. Apart from integration with RBIA, there are other possible approaches, on-line and/or off-line.

(2) Client Access from Remote Offices

The RSMS database application system is designed so a client PC can access the database via the network. Only the RSMS client application should be installed in the client PC with no license fee.

(3) Distribute Copies of the Database to the Remote Offices

Some District Engineering Offices have no WAN connections with the Central Office. Like the RBIA application, it is possible to distribute copies of the database to the local offices.

4.5 Method of Risk Management Planning

4.5.1 Policy/ Program Making by DPWH Central Office

The inventory survey/ RSMS database can provide risk level indicators for the evaluation of the effectiveness of slope disaster prevention projects and the setting of the next stage target level. Planning should be done utilizing the RSMS database through the process of;

(1) Assessment of the risk level of RCD of a road section under current state, IATEp and IALp, by processing FRCDp and Annual Loss (AL) of individual slopes,
(2) Data collection of reference values for target-setting,
(3) Target-setting for risk level indicators by IRCDt, IATEt, and IALt,
(4) Prioritization of road sections for risk management using the benefit defined as the difference of IALp and IALt, and
(5) Direction from CO to local offices for planning the disaster prevention projects and risk avoidance management system.

4.5.2 Risk Management Planning by RO's and DEO's

ROs and DEOs will plan 'Slope Disaster Prevention Projects' and 'Risk Avoidance Management Systems' based on the list of road sections of the various risk management priority classifications and the slope inventory.

4.6 Outline of Technical Guide

Three (3) kinds of technical guides, Guide I, II, and III, to support implementation of RSMS have been prepared as shown in Table 4.1.

Table 4.1 Contents and Users of Guide

Volume No. of Final Report	Title of Volume	Contents	Main Users in DPWH
Guide I	Guide to Risk Management Planning on Road Slopes	1. Formulation and utilization of road slope management database 2. Target setting and programme formulation for risk management 3. Project formulation for disaster prevention	**Central Office** (Information & Communication Technology Service, Planning Service, Bureau of Maintenance) **Regional Office** **District Engineering Office**
Guide II	Guide to Inventory Survey and Risk Assessment on Road Slopes	4. Procedures for inventory survey - Assessment of Potential Road Closure Disaster (FRCDp) - Assessment of disaster magnitude and other disaster situation - Alternative Countermeasure planning and cost estimates - Indicative Feasibility Assessment (IFA)	**Central Office** (Planning Service, Bureau of Maintenance) **Regional Office** (Planning and Design Division, Maintenance Division) **District Engineering Office** (Planning and Design Section, Maintenance Section)
Guide III	Guide to Road Slope Protection	7. Countermeasure design method 8. Countermeasure design example 9. Temporary treatments for road slope disasters and quality control for restoration work	

4.7 Risk Avoidance Management

The purpose of the early warnings and regulation of traffic is to protect human lives. In case of the early warning and regulation of traffic during the heavy rainfall, the saving of human lives and the detour cost are tradeoffs. Therefore, reasonable and effective risk avoidance management method should be established using the RSMS database and other information such as the rainfall data.

CHAPTER 5 RESULTS OF PILOT INVENTORY SURVEY

5.1 Results of Preliminary Inventory Survey

5.1.1 Selection of Road Sections for PIS

The selection of road sections for the Inventory Survey was carried out considering the criteria consisting of 1) Security in the area, 2) Accessibility, 3) Coverage of all kinds of disaster types, 4) Equitable regional distribution, 5) Suggestions from DPWH, and 6) Present condition of the road.

5.1.2 Result of Preliminary Inventory Survey

Sixteen National Highway road sections in six Regions were selected for the pilot PIS. Along the 332 km of road sections, 1,933 slopes were surveyed based on the PIS criteria. Results indicate that around 61% had a high risk level that required the DIS. The most dominant Disaster Type was found out to be RS (41%), followed by SC (28%) and RC (16%). The summary of the PIS results is shown in Table 5.2.

5.2 Result of Detailed Inventory Survey

5.2.1 Selection of Road Sections for DIS

Road Sections surveyed for the DIS were selected from the PIS Road Sections according to the criteria consisting of 1) Equitable regional distribution, 2) Conduct by many responsible DEOs, 3) Priority sections by DEO, and 4) Disaster Types as many as all.

5.2.2 Result of the Detailed Inventory Survey

Results of DIS are summarized in Table 5.3, where countermeasures are set as in Table 5.1

Table 5.1 Countermeasure Alternative Policy

Alternative	Effectiveness	Risk Reduction Ratio
Alternative-I	High Effectiveness: Permanent countermeasures to prevent disasters	0.7-1.0 (70%-100%)
Alternative-II	Moderate Effectiveness: Mitigating the disasters to some extent	0.3– 0.7 (30%- 70%)
Alternative-III	Low Effectiveness: Limited treatment	0.0-0.3 (0-30%)

Table 5.2 PIS Result of Study Road Sections

Region	Road Section	Section (km)	Length (km)	Office in Charge (DEO)	Preliminary Inventory Survey Disaster Type								Detailed Inventory Survey Disaster Type							
					SC	RC	LS	RS	DF	RE	CE	Total	SC	RC	LS	RS	DF	RE	CE	Total
CAR	Kennon Rd	241 - 244	3	Baguio City	8	15	0	9	12	0	0	**44**	5	5	0	7	0	0	0	**17**
		214 - 241	27	Benguet 1st	31	54	0	88	9	34	0	**216**	15	51	0	27	5	20	0	**118**
	Baguio-Bontoc Rd	263 - 341	78	Benguet 2nd	125	76	2	153	30	0	0	**386**	113	70	2	116	17	0	0	**318**
	Nueva Vizcaya-Ifugao-Mt. Province Rd	301 - 333	32	Ifugao	91	24	4	72	54	0	0	**245**	72	22	4	22	18	0	0	**138**
	Sub-total		**140**		**255**	**169**	**6**	**322**	**105**	**34**	**0**	**891**	**205**	**148**	**6**	**172**	**40**	**20**	**0**	**591**
II	Daang Maharlika (LZ)	208 - 220	12	Nueva Vizcaya Sub	31	27	0	37	17	6	0	**118**	11	23	0	9	5	2	0	50
	Sub-total		**12**		**31**	**27**	**0**	**37**	**17**	**6**	**0**	**118**	**11**	**23**	**0**	**9**	**5**	**2**	**0**	**50**
VII	Cebu-Balamban Transcentral Highway	5 - 30	25	Cebu City	59	29	0	92	2	0	0	**182**	30	25	0	28	2	0	0	**85**
		30 - 42	12	Cebu 3rd	21	10	0	68	9	0	0	**108**	15	10	0	16	4	0	0	**45**
	Toledo-Baliri-Santander Rd	143 - 179	36	Cebu 4th	11	18	0	4	0	14	76	**123**	6	18	0	0	0	7	58	**89**
	Sub-total		**73**		**91**	**57**	**0**	**164**	**11**	**14**	**76**	**413**	**51**	**53**	**0**	**44**	**6**	**7**	**58**	**219**
VIII	Wright-Taft-Borongan Rd	843 - 859	16	Samar 2nd	18	9	0	34	4	0	0	**65**	10	7	0	17	2	0	0	**36**
	Daang Maharlika (LT)	995 - 1003	8	Leyte 5th	20	0	0	26	0	8	0	**54**	9	0	0	6	0	5	0	**20**
		1003 - 1018	15	Southern Leyte	41	18	2	38	9	0	0	**108**	33	18	2	20	7	0	0	**80**
	Sub-total		**39**		**79**	**27**	**2**	**98**	**13**	**8**	**0**	**227**	**52**	**25**	**2**	**43**	**9**	**5**	**0**	**136**
X	Misamis Or-Bukidnon-Agusan Rd	1428 - 1464	36	Bukidnon 3rd	69	20	0	157	1	1	0	**248**	60	18	0	71	0	0	0	**149**
	Bukidnon-Davao City Rd	1605 - 1607	2	Bukidnon 2nd	6	1	0	2	0	0	0	**9**	6	1	0	2	0	0	0	**9**
	Sub-total		**38**		**75**	**21**	**0**	**159**	**1**	**1**	**0**	**257**	**66**	**19**	**0**	**73**	**0**	**0**	**0**	**158**
XI	Davao-Cotabato Rd	1525 - 1555	30	Davao Del Sur 1st	2	0	0	4	0	21	0	**27**	2	0	0	2	0	12	0	**16**
	Sub-total		**30**		**2**	**0**	**0**	**4**	**0**	**21**	**0**	**27**	**2**	**0**	**0**	**2**	**0**	**12**	**0**	**16**
TOTAL			**332**		**533**	**301**	**8**	**784**	**147**	**84**	**76**	**1933**	**387**	**268**	**8**	**343**	**60**	**46**	**58**	**1170**

Table 5.3 Result of Detailed Inventory Survey

REGION	ROAD NAME	SECTION	LENGTH (km)	DEO IN CHARGE	Nos. of Slopes	ANNUAL LOSS		COUNTERMEASURE ALTERNATIVE I		COUNTERMEASURE ALTERNATIVE II		COUNTERMEASURE ALTERNATIVE III	
						Total (Pesos per year)	IALp* (pesos per year*km)	Cost (Pesos)	Annual Benefit IALpwc-IALp [pesos per (year*km)]	Cost (Pesos)	Annual Benefit IALpwc-IALp [pesos per (year*km)]	Cost (in Pesos)	Annual Benefit IALpwc-IALp [pesos per (year*km)]
CAR	Kennon Rd	240 - 243	3	Baguio City	10	3,884,667	1,294,889	33,849,028	33,849,028	21,438,940	2,344,037	466,755	39,711
		227 - 234	7	Benguet 1st	32	647,656,677	92,522,382	421,111,616	582,891,009	141,435,398	388,594,006	1,910,237	97,130,336
	Baguio-Bontoc Rd	275 - 280	5	Benguet 2nd	43	111,415,484	22,283,097	113,199,129	98,087,744	63,918,843	60,055,398	10,850,230	17,605,308
	Nueva Vizcaya-Ifugao-Mt. Province	301 - 306 318 - 323	10	Ifugao	33	62,580,132	6,258,013	126,665,797	54,274,332	104,979,029	34,619,864	45,782,520	8,548,919
Sub-total			**25**		**118**	**825,536,960**	**122,358,381**	**694,826,570**	**769,102,113**	**331,772,210**	**485,613,305**	**59,009,742**	**123,324,274**
Average							***4,894,335***						
II	Daang Maharlika (LZ)	208 - 213	5	Nueva Vizcaya Sub	27	67,798,037	13,559,607	109,056,992	58,029,762	96,463,084	42,975,857	64,585,880	10,101,673
Sub-total			**5**		**27**	**67,798,037**	**13,559,607**	**109,056,992**	**58,029,762**	**96,463,084**	**42,975,857**	**64,585,880**	**10,101,673**
Average							***2,711,921***						
VII	Cebu-Balamban Transcentral Highway	27 - 30	3	Cebu City	19	26,334,624	8,778,208	75,112,940	23,640,758	36,622,925	16,755,175	23,719,898	7,794,244
		33 - 37	4	Cebu 3rd	28	9,966,200	2,491,550	117,084,822	8,965,457	63,210,941	5,955,050	12,211,684	985,578
	Toledo-Baliri-Santander Rd	172 - 176	4	Cebu 4th	4	86,002	21,501	14,543,780	82,127	10,799,738	56,768	3,238,464	16,883
Sub-total			**11**		**51**	**36,386,826**	**11,291,259**	**206,741,542**	**32,688,341**	**110,633,604**	**22,766,993**	**39,170,046**	**8,796,705**
Average							***1,026,478***						
VIII	Wright-Taft-Borongan Rd	844 - 847	3	Samar 2nd	13	356,663,974	118,887,991	53,321,928	262,444,500	33,039,454	252,465,598	8,833,304	3,241,651
	Daang Maharlika (LT)	1000 - 1003	3	Leyte 5th	9	23,808,217	7,936,072	38,145,615	22,842,493	35,775,453	16,452,079	25,785,383	7,142,465
		1003 - 1007	4	Southern Leyte	26	56,322,764	14,080,691	113,501,738	45,433,985	320,527,157	29,972,682	68,440,980	13,265,301
Sub-total			**10**		**48**	**436,794,955**	**140,904,755**	**204,969,281**	**330,720,977**	**389,342,064**	**298,890,358**	**103,059,667**	**23,649,417**
Average							***14,090,475***						
TOTAL			**51**		**244**	**1,366,516,778**	**288,114,002**	**1,215,593,385**	**1,190,541,194**	**928,210,962**	**850,246,514**	**265,826,335**	**165,872,069**

IALp: Potential Intensity of Annual Loss: (Total Annual Loss of a Road Section)/ (Length of a Road Section) [pesos per (year*km)]

IALpwc: IALp with Counter Measure (IALp * RRR); RRR: Risk Reduction Ratio, Alternative I RRR: 0.7 - 1.0, Alternative II RRR: 0.3 - 0.7, Alternative III RRR 0.7 – 1.0

CHAPTER 6 FEASIBILITY STUDY

6.1 General

Feasibility studies have been carried out for five sites selected as model studies. The feasibility study is composed of five tasks: Field Survey, Initial Environmental Examination (IEE), Social Survey, Countermeasure Design, and Feasibility Assessment.

6.2 Selection of Survey Slopes and Study Method

6.2.1 Selection of Study Sites

Selection criteria are 1) Equitable regional distribution, 2) Security and safety of the area, 3) Slopes requested by RO and DEO, 4) Urgency of the need for a countermeasure, and 5) Applicability of various engineering methods.

Five sites from five Regions were selected as feasibility study sites based on the selection criteria. The disaster types selected are Road Slips (RS), Landslides (LS) and Costal Erosion (CE), which are the most common disasters that require proper solutions to improve the traffic function of the national highways.

6.2.2 Study Items

The survey items for each study site are shown in Table 6.1.

6.3 Countermeasure Design and Cost Estimates

For each of the study sites, based on the identified Disaster Type, outcomes of the Inventory Survey and results of the field investigation, preliminary design and cost estimates for a few optional countermeasures were carried out, and an optimal option from the engineering aspect was selected.

In the cost estimate, the engineering unit costs are composed of the material, labor, and equipment costs, as well as the indirect costs including the overhead of expenses (5% of labor cost), contingency (10% of direct cost), miscellaneous expenses (1% of direct cost), value-added tax (12% of labor and equipment costs), and contractor's administration cost and profit (10% of direct cost).

Each option is evaluated from four aspects consisting of the construction cost, construction risk and easiness, structural reliability, and social environmental aspect, each being evaluated by any of three ranks of good, fair, and poor. Furthermore, each aspect is weighted with a rating factor judged from its relative importance.

The overall results of countermeasure design and cost estimates for five sites are summarized as in Table 6.2.

Table 6.1 Work Item for Five Study Sites

Work Item		Kennon Rd 232 km	Lagawe Banaue 301 km	Dalton Pass 211 km	Ginatilan Alegria 172 km	Wright Taft 846 km
(1) Review of Inventory Survey Data(T)		Y	Y	Y	Y	Y
(2) Engineering Inspection(T)		Y	Y	Y	Y	Y
(3) Field Survey(C)	3.1 Topographic Survey	Y	Y	Y	Y	Y
	3.2 Geo- Engineering Inspection	Y	Y	Y	Y	Y
	3.3 Drilling Work		Y	Y	Y	Y
	3.4 Sounding for Foundation	Y	Y	Y	Y	Y
	3.5 Ground Water Logging		Y	Y	Y	Y
	3.6 Ground Water Monitoring	Y	Y	Y	Y	Y
	3.7 Pipe Strain Gauge Monitoring		Y			Y
	3.8 Movable Stake Installation		Y	Y		Y
(4) Initial Environmental Examination(IEE)(T)		Y	Y	Y	Y	Y
(5) Social Survey (T)		Y	Y	Y	Y	Y
(6) Countermeasure Designing (T)		Y	Y	Y	Y	Y
(7) Feasibility Assessment (T)		Y	Y	Y	Y	Y

Note Y; done, Blank; not done
(T); Conducted by Study Team and Counterpart Team, (C); Local Consultant

6.4 Environmental and Feasibility Assessment

At this early stage, it is apparent that the viability of any of the countermeasures will be low, given that these interventions should have been done at the time that the road was constructed. Thus, in the conduct of the feasibility study for the roads, its viability should have been determined inclusive of the costs of countermeasures to insure that its function would be sustained throughout its economic life. The summary of the results of the feasibility evaluation of the projects selected for the conduct of feasibility studies are given in Table 6.3.

The proposed projects are intended to mitigate/avoid the occurrence of slope disasters on national highways and are thus not subject to the conduct of an Environmental Impact Assessment. What is needed would be for the DPWH to secure a Certificate of Non-Coverage from the DENR office in the region where the proposed projects are located.

As for the social impact, the proposed sites have no/minimal human activity and residents.

Table 6.2 Summary of Engineering Results of Model Feasibility Study

Road Slope Location	Disaster Type	Countermeasure Options	Cost Estimate PHP Million
Kennon Road Km 232	RS	**Reinforced Embankment by Terre Arme Wall**	**18.5**
		Crib Grouted Riprap Retaining Wall	15.1
		Shelf Type Reinforced Concrete Retaining Wall	13.4
Nueva Vizcaya-Ifugao-Mt. Province Rd. Km 301	LS	Horizontal Drain Holes + Steel Pipe Piles	41.2
		Horizontal Drain Holes + Counterweight Embankment	**22.6**
Daang Maharlika (LZ) Km 211	RS	Leaning Concrete Wall + Concrete Block Masonry Wall	5.7
		Double Concrete Block Walls	**4.2**
Toledo- Baliri-Santander Rd. Km 172	CE	Blanket Concrete Type Revetment	5.6
		Gravity Type (Leaning Wall Type) Revetment	**4.3**
Wright-Taft-Borongan Rd. Km 846	RS	**Drainage system + Gravity Concrete Wall**	**14.6**
		Drainage system + Reinforced Concrete Cantilever Wal	16

Options in bold letters judged to be the optimal countermeasure

Table 6.3 Summary of Economic Feasibility Assessment

Road Slope Location	Disaster Type	Countermeasure Options	Feasibility Assessment		
			EIRR	B/C at 15% DR	NPV at 15% DR
Kennon Road Km 232	RS	Reinforced Embankment by Terre Arme Wall	-6.0%	0.19	PHP -14.0 Million
Nueva Vizcaya-Ifugao-Mt. Province Rd. Km 301	LS	Horizontal Drain Holes + Counterweight Embankment	-3.9%	0.21	PHP -16.8 Million
Daang Maharlika (LZ) Km 211	RS	Double Concrete Block Walls	97.1%	7.61	PHP 25.1 Million
Toledo- Baliri-Santander Rd. Km 172	CE	Gravity Type (Leaning Wall Type) Revetment	11.7%	0.92	PHP -0.8 Million
Wright-Taft-Borongan Rd. Km 846	RS	Drainage system + Gravity Concrete Wall	4.2%	0.49	PHP -7.7 Million

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

7.1.1 Formulation of the Road Slope Management System (RSMS)

(1) Major Outputs of the Study

The RSMS has been established with close cooperation between the JICA Study Team and DPWH Counterpart Team.

(2) Technical Guides

A technical guide that support actual inventory surveys and risk management planning has been prepared in three Volumes comprising Guide I to Risk Management Planning on Road Slopes, Guide II to Inventory Survey and Risk Assessment on Road Slopes, and Guide III to Road Slope Protection. These technical Guides were prepared, considering the current road disaster situation, and revised and refined in the process of executing the pilot Inventory Survey.

7.1.2 Capability of DPWH on RSMS

This Study was carried out jointly by the JICA Study Team and the DPWH Counterpart Team, which periodically reported to, and were authorized by, the Technical Working Group and the Steering Committee.

(1) Capability of DPWH Engineers

Technical transfer on the procedure of the Inventory Surveys has been conducted in four ways including (1) Joint work with the JICA Study Team, (2) On-the-Job training in the Study, (3) Seminars/Workshops, and (4) Counterpart training in Japan. Through the activities in each of the training programs, the DPWH engineers acquired the skills needed to complete the Inventory Surveys properly and mastered the various kinds of skills needed for the work.

The lack of geotechnical engineers with advanced knowledge of the technology for slope engineering is the only issue affecting the quality of the Inventory Surveys for the nationwide national highways. Thus, securing and training engineers in slope engineering is a key program to be implemented in order to execute the nationwide Inventory Surveys.

(2) Organization of DPWH

Throughout the Study, all work has been successfully completed using the existing DPWH command structure and systems. Coordination among the Central Office, Regional Offices and District Engineering Offices has worked smoothly. It has been proven that the DPWH organization functions adequately to carry out this kind of work. The pilot Inventory Survey was a simulation to illustrate how to execute the nationwide inventory surveys, and it demonstrated the potential capability of DPWH for the work in both the technological and institutional aspects.

7.2 Recommendations

7.2.1 New Risk Management for Slopes along National Highways

To improve the situation for providing reliable traffic on the national highways, it is recommended that timely risk management be applied to the critical sections by the new methods developed in the Study

7.2.2 Organization to Promote Nationwide Road Slope Risk Management

(1) Flow of New Risk Management Method

It is estimated that it will require roughly two years to formulate a risk management plan for road slope disasters on national highways nationwide, including preparatory seminars/workshops, inventory surveys, encoding to a database, and risk management planning.

(2) Organization for Implementation of Nationwide Road Slope Inventory Survey

The road slope inventory survey for national highways nationwide will be implemented by the "Inventory Survey Team", consisting of the Central Office, Regional Offices and District Engineering Offices of DPWH. The recommended composition of the "Inventory Survey Team" is basically the same as that used in the pilot Inventory Survey conducted in this Study. The responsible unit in the Central Office is the DPD, Planning Service and the executing units in ROs and DEOs are the Maintenance Divisions and Maintenance Sections, respectively. And, the ROs and DEOs which conducted the pilot Inventory Survey shall be the leading units for the prospective nationwide inventory surveys. Also, the staff who participated in the pilot Inventory Surveys preferably should be assigned as members of the "Inventory Survey Team" to make use of their expertise and experience in the pilot Inventory Survey, database formulation, and risk management planning.

7.2.3 Formulation of Systematic and Reasonable Risk Management Plan

The PMS (Pavement Management System) and the BMS (Bridge Management System) have been established to support needs analysis, multi-year programming and annual budgeting for the preservation of road pavement and bridges on the national network. The RSMS developed in this Study is an application to complement the two applications mentioned above. The establishment of the RSMS in close linkage with the PMS and the BMS will enable the formulation of a reasonable and balanced multi-year risk management program for road slopes along the national highways. The constant allocation of resources to the "Comprehensive Road Maintenance and Risk Management Program" is strongly recommended in order to gain control of RCDs on the national highways. Adequate budget support will ensure the success of the program.

7.2.4 Improvement of Design and Construction Method

One of the major targets in controlling RCDs is the reduction of recurrence. To reduce the recurrence of RCDs, the basic procedures for the design and construction methods shall be improved from the viewpoint of slope engineering. For example, suitable drainage works for critical slopes often prevent the progress of deformation, especially in Road Slips or Soil Collapses. Also, a suitable cut slopes gradient should be applied to secure slope stability.

The introduction of advanced countermeasures to some key slopes is recommended to ensure the safe and smooth road traffic. In many places insufficient countermeasures to prevent recurrence of RCDs had been applied on critical and adverse slopes. Suitable technological development in such an engineering field is very important to suitably treat and manage such dangerous slopes.

The Study developed an inventory survey system for road slopes, named the RSMS. This may be only a part of the activities of DPWH to reform the work processes to provide road users with safe and smooth traffic. But the Study Team sincerely hopes that the RSMS would be utilized appropriately, coordinated with PMS and BMS to formulate systematic and reasonable multi-year programs that will contribute to the improvement of the traffic function on the national highways of the Philippines.