CHAPTER 21

PROJECT EVALUATION

CHAPTER 21 IMPLEMENTATION PLAN

21.1 General

In this Chapter, the implementation plan of the road disaster prevention spots is addressed taking account of the key aspects which affect implementation. These include; executing agency, construction period, construction packages, preparatory works, implementation schedule and investment.

21.2 Executing Agency

The General Division of Planning, Ministry of Transport and Infrastructure (GDP), is the responsible government agency for the execution of the implementation of the Project. The Cooperation and Economic Relationship Office, Ministry of Foreign Affairs, is also the executing agency for supporting the Ministry of Transport and Infrastructure in donor assisted projects.

21.3 Project Packaging

As described in Chapter 20, three work packages result from the economic evaluation, and cost-effectiveness considerations. Package One contains disaster spots of NIC.1, NIC.3 and NIIC.26. Package Two contains sites on NIC.3, NIC.5 and NIC.1. Package Three sites are restricted to NIC.1 and NIC.3. The order of implementation is related to the cost effectiveness of the construction works. The relationship of the package groupings and the disaster spots are shown in Table 21.2.1.

Table 21.3.1 Package Group and Disaster Spots

	Nic1	Nic3	Nic5	Nic26	合計(箇所)
Package1	N001A280 Junquillal San Nicolas San Ramon N001A240 N001B230 N001B150	N003B400 N003B320		N026A160 San Juan de Dios Papalon	12
Package2	N001A290	N003B370 El Guayacan N003E170	N005A010	La Banderita Solis	7
Package3	Las Chanillas N001B170 N001B120 Rio Inali Rio Tapacali	N003C230 N003C150 N003C140		N026A060 N026B140 N026A150	11

21.4 Validity Evaluation to Each Countermeasure

21.4.1 Review to Each Countermeasure

Based on the countermeasures for the disaster critical spots in Part A, each countermeasure has been studied in detail in Chapter 17. The detailed study reflected the fact that conditions such as slope stability and falling rocks at each disaster spot are very different during the dry the rainy seasons. In addition, the existing geometries of some disaster spots do not allow sufficient width for falling rocks.

The countermeasures for the disaster prevention spots have been determined by considering slope condition, importance of the objective road, the socio-economic situation of the surrounding area and potential emergencies.

21.4.2 Validity of Environmental Issue

The following environmental impacts on NIC.3 have been identified.

- An impact on the hotel under construction by re-cutting the slope (N003B320),
- An impact on the natural park through re-cutting the slope without vegetation (N003C230),
- An impact on the downstream area, where is a rice field, due to blocking the mountain stream by constructing the dam (N003E170), and
- An impact on the coffee field through embanking the downside of the slope (N003C140).

However the above-mention issues have been reviewed in consideration of the following countermeasures.

- The hotel of "N003B320 spot" will be safeguarded by constructing a retaining wall without re-cutting the slope,
- The natural park of "N003C230 spot" will be protected by planting vegetation into the cribwork after re-cutting the slope,
- The downstream area of "N003E170 spot", where the mountain stream could be blocked, will be continue to be irrigated through an opening in the dam, and
- The coffee field of "N003C140 spot" will be safeguarded by constructing a retaining wall in order to reduce the embankment reach.

Thus, the issues related to the environment of each disaster spot have been completely settled by appropriate mitigation measures. Therefore each countermeasure is valid in relation to the environment aspects.

21.4.3 Validity of the Result of Economic and Financial Analysis

The construction costs, including measures to compensate for environmental impacts, have been included in the economic evaluation (Chapter 20). Table 21.4.2 lists the additional factors which have an economic and financial impact for each of the recommended countermeasures.

Most of the schemes will require some maintenance. The costs of maintenance of the permanent schemes were included in the economic evaluation at 2% of capital cost (Table 20.1.4). The resultant maintenance cost requirements are summarised in Table 21.4.1.

Table 21.4.1 Annual Maintenance Budget Estimates (US$, 2002 prices)

Package	Annual Maintenance Cost ($)
1	12,167
2	66,263
3	175,911
Total	254,340

Source : 2% of capital costs of permanent works

The sum total in Table 21.4.1 should be safeguarded for maintenance, to be deployed after the capital works have been undertaken. This sum is accounted for in the economic evaluation and hence the economic evaluation is valid. In addition, the sum in Table 21.4.1 will be sufficient to cover the required maintenance works identified in Table 21.4.2.

Table 21.4.2 Validity of Economic and Financial Evaluation

Site	*Countermeasure*	*Effect on traffic during construction*	*Maintenance Consequences*	*Validity*
N001A290	Removal of loose rocks, installation of netting and drainage	None	Depends on durability of the metal netting	No economic or financial effect
N001A280	Horizontal drainage	Traffic control-one way working during drilling	Monitoring water quality	Small economic disbenefit to traffic during construction
N001A240	Removal of loose rocks, installation of netting	None	Depends on durability of the metal netting	No economic or financial effect

Site	Countermeasure	Effect on traffic during construction	Maintenance Consequences	Validity
N001A230	Removal of loose rocks, installation of netting	None	Depends on durability of the metal netting	No economic or financial effect
N001B170	Cutting and drainage	Probable need for one-lane traffic working	Maintenance required until vegetation matures	Small economic disbenefit to traffic during construction
N001B150	Cutting, shotcrete and drainage	None	Monitoring water currents	No economic or financial effect
N001B120	Cutting and drainage	Probable need for one-lane traffic working	Maintenance of slope condition	Small economic disbenefit to traffic during construction
N003B400	Cutting and drainage	Probable need for one-lane traffic working	Regular inspection of slope condition	Small economic disbenefit to traffic during construction
N003B370	Cutting and drainage	Probable need for one-lane traffic working	Regular inspection of slope condition	Small economic disbenefit to traffic during construction
N003B320	Retaining wall and fill, plus drainage and re-vegetation	None	None	No economic or financial effect
N003C230	Cutting and concrete protection with vegetation, and lower down embankment plus drainage	Road reduced to one lane	Regular maintenance required until vegetation matures	Small economic disbenefit to traffic during construction
N003E170	Cutting, drainage, concrete dam and culvert beneath road	Re-alignment of road during construction	None	No economic or financial effect
N003C150	Cutting and drainage above road, embankment, vegetation and drainage below	Road reduced to one lane	Regular maintenance required until vegetation matures	Small economic disbenefit to traffic during construction
N003C140	Cutting with drainage and horizontal drainage above road, embankment, vegetation and drainage below	Road reduced to one lane	Regular maintenance required until vegetation matures	Small economic disbenefit to traffic during construction
N005A010	Cutting and drainage	Road reduced to one lane	Regular maintenance of the slope	Small economic disbenefit to traffic during construction
N0026A060	Cutting, shotcrete and drainage	Probable need for one-lane traffic working and control	Monitoring water movement	Small economic disbenefit to traffic during construction

Site	Countermeasure	Effect on traffic during construction	Maintenance Consequences	Validity
N0026B140	Cutting, drainage and horizontal drainage	Road reduced to one lane	Regular maintenance required until vegetation matures	Small economic disbenefit to traffic during construction
N0026B150	Cutting and drainage, lateral carriageway drainage	Road reduced to one lane	None	Small economic disbenefit to traffic during construction
N0026B160	Removal of loose rocks, installation of netting and drainage	None	Depends on durability of the metal netting	No economic or financial effect
NIC.1-Junquillal	Gabion mat	None	Periodic Maintenance	No economic or financial effect
NIC.1-San Nicolás	Gabion mat	None	Periodic Maintenance	No economic or financial effect
NIC.1-Las Chanillas	Concrete Block	None	Periodic Maintenance	No economic or financial effect
NIC.1-San Ramón	Gabion mat	None	Periodic Maintenance	No economic or financial effect
NIC.1-Rio Inalí	Gabion mat and stone masonry	None	Periodic Maintenance	No economic or financial effect
NIC.1-Rio Tapacalí	Gabion mat	None	Periodic Maintenance	No economic or financial effect
NIC.3-El Guayacán	New Bridge	Temporary bridge during construction	Periodic Maintenance	Additional construction cost
NIC.26-Papalón	Gabion mat and riprap with mortar	None	Periodic Maintenance	No economic or financial effect
NIC.26-Solís	Gabion mat and riprap with mortar	None	Periodic Maintenance	No economic or financial effect
NIC.26-La Banderita	Masonry wall and gabion mat	None	Periodic Maintenance	No economic or financial effect
NIC.26-San Juan de Dios	Gabion mat	None	Periodic Maintenance	No economic or financial effect

Source : Consultant's evaluation

At the spots listed above where there will be a need for single-lane traffic working during construction, it is assumed that this will be controlled by temporary traffic signals, or manually. In both cases, traffic can expect to be delayed, depending on the length of road affected. This length affects the time taken for vehicles to clear when both directions are halted, and increases the disbenefit. Even a relatively long section (150m) should clear in 30 seconds. The maximum resultant disbenefits for each of the sires would be less 30 vehicle-hours per day. In monetary values these will always be much less than 1% of the potential benefits of the works, and the traffic disbenefits can be considered to be negligible. Hence the economic evaluation is valid.

21.4.4 Validity Evaluation of the Countermeasures

As above-mentioned, the countermeasures are have been validated from the results of the environmental impacts and the economic analyses. Furthermore, almost all of the construction materials and the construction machines are readily available in Nicaragua. The proposed total investment in the disaster prevention schemes has been evaluated below (as opposed to the individual scheme evaluations reported in Chapter 20). The total investment is listed in Table 21.4.3.

Table 21.4.3 Total Investment in Disaster Prevention Measures (US $, 2002 prices)

Year	*Capital*	*Maintenance*
2002		
2003	30,918	
2004	235,330	
2005	965,950	
2006	2,632,236	
2007	5,383,945	11,451
2008	3,468,608	90,374
2009	0	207,253
2010	0	207,253
2011	0	207,253
2012	0	207,253
2013	0	207,253
2014	0	207,253
2015	0	207,253
2016	0	207,253
2017	2,354,358	207,253
2018	0	207,253
2019	0	207,253
2020	0	207,253
Total	15,071,345	2,588,856

Source : Tables 18.6.1, 18.6.2, 18.6.3, 18.6.4, 18.6.5, 18.6.6, 18.6.7, 20.1.3, 21.8.1

The benefits from this investment are due to the prevention of disasters at all 30 spots. The Internal Rate of Return of this project in avoiding disasters at each of the following sites over the next 10 years is set out in Table 21.4.4.

Table 21.4.4 Project Internal Rate of Return (EIRR) in Preventing Disasters on Each Road Link : Full Project Cost in Each Case

Link	*Road*	*EIRR(%)*
Malpaisillo	NIC.26	27.9
Sebaco to Chagatuillo	NIC.3	28.2
La Sirena to Condega	NIC.1	15.5
Average		23.5

Source : Project Evaluation Spreadsheets

The average EIRR for all the sites is 23.5%. This means that the project rate of return for the prevention of just one disaster is 23.5%, and the rate of return for preventing more than disaster will be higher. Therefore, the countermeasures planned through this Study are highly applicable to preventing the road disasters in Nicaragua.

21.5 Construction Period of Each Project Packaging

The construction period for each project package was estimated taking account of the work volume, site condition, weather condition, right-of-way situation, etc. The disaster spots have been divided into three categories, described as follows.

◆ **Package 1: Priority Site 1**

The disaster spots of Priority Site 1 are composed of NIC.1, NIC.3 and NIC.26. The main work items are to install gabion mats to prevent scouring of bridge foundations, to cut the weathered and steep slope surfaces, and to installation drainage and retaining walls. The detailed works are shown in Table 21.5.1. The estimated construction period for this package is 2 years.

Table 21.5.1 Construction Work of Package 1

Road No.	ID No.	Countermeasure	Total
Nic.1	N001AA280	Horizontal drainage	7
	Junquillal	Gabion mat	
	San Nicolás	Gabion mat	
	San Ramón	Gabion mat	
	N001A240	Removal of loose rocks, installation of netting	
	N001B230	Removal of loose rocks, installation of netting	
	N001B150	Cutting, shotcrete and drainage	
NIC.3	N003B400	Cutting and drainage	2
	N003B320	Retaining wall and fill, drainage and re-vegetation	
NIC.26	N026B160	Removal of loose rocks, Installation of netting and drainage	3
	San Juan de Dios	Gabion mat	
	Papalón	Gabion mat and riprap with mortar	

◆ **Package 2 : Priority Site 2**

The disaster spots of Priority Site 2 are composed of NIC.3, NIC.5 and NIC.26. The main work items are the construction of a new bridge, to install gabion mats, to cut the weathered and steep slope surfaces, and to install drainage. The detailed works are shown in Table 21.5.2. The estimated construction period for this package is 2 years.

Table 21.5.2 Construction Work of Package 2

Road No.	ID No.	Countermeasure	Total
NIC1	N001A290	Removal of loose rocks, Installation of netting and drainage	1
NIC.3	N003B370	Cutting and drainage	3
	El Guayacán	New bridge	
	N003E170	Cutting and drainage, concrete dam and Box culvert	
NIC.5	N005A010	Cutting and drainage	1
NIC.26	La Banderita	Masonry wall and gabion mat	2
	Solis	Gabion mat and riprap with mortar	

◆ **Package 3 : Priority Site 3**

The disaster spots of Priority Site 3 are composed of NIC.1 and NIC.3. The main work items are to install gabion mats to prevent scouring of bridge foundations, to cut the weathered and steep slope surfaces, and to install drainage. The detailed works are shown in Table 21.5.3. The estimated construction period for this package is 2 years.

Table 21.5.3 Construction Work of Package 3

Road No.	ID No.	Countermeasure	Total
NIC.1	Las Chanillas	Concrete brocks	5
	N001B170	Cutting and drainage	
	N001B120	Cutting and drainage	
	Rio Inali	Gabion mat and stone masonry	
	Rio Tapascali	Gabion mat	
NIC.3	N003C230	Cutting and concrete protect with vegetation, Lower down embankment with drainage	3
	N003C150	Cutting and drainage above road, embankment, Vegetation and drainage below	
	N003C140	Cutting with drainage and horizontal drainage above road, embankment, vegetation and drainage below	
NIC.26	N026A060	Cutting, shotcrete and drainage	3
	N026B140	Cutting, drainage and horizontal drainage	
	N026A150	Cutting and drainage, lateral carriageway drainage	

21.6 Engineering Services

The proposed Engineering Services comprise two main components. The preparatory work is required to be implemented before the commencement of the project packages, and includes a detailed design and a tendering for the construction works. After tendering for construction, the supervision of construction work will be assigned during construction period. The total required period of the Engineering Services is 5 years.

21.7 Implementation Schedule

The implementation schedule was set up taking account of the construction period estimated for each project package and for the engineering services. The recommended implementation schedule is shown in Figure 21.7.1.

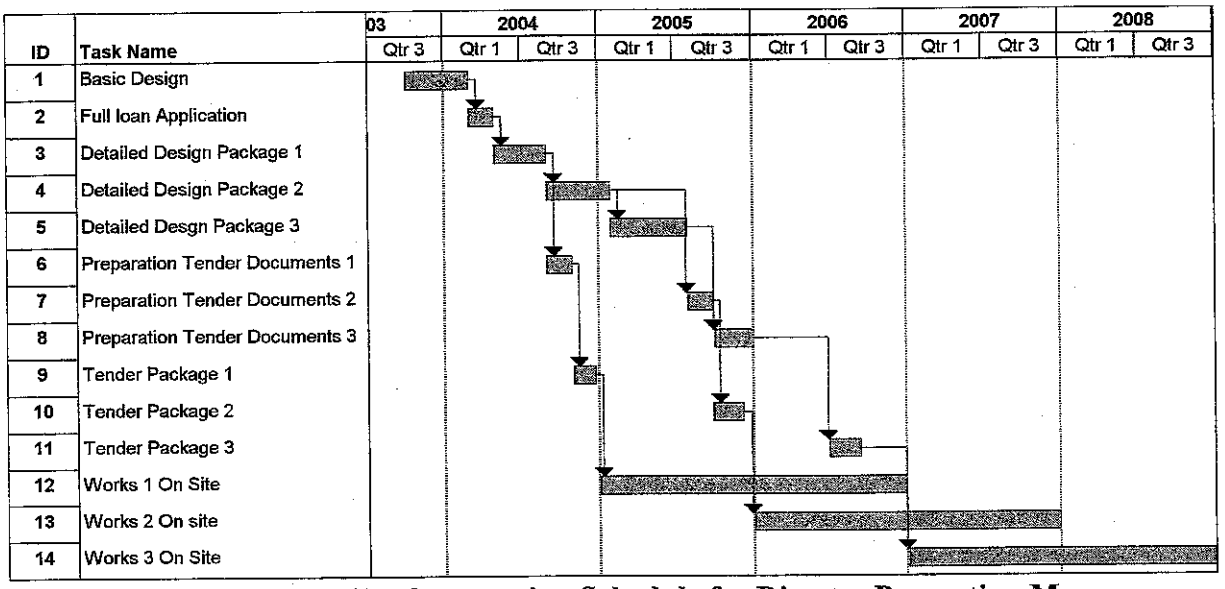


Figure 21.7.1 Proposed Implementation Schedule for Disaster Prevention Measures

21.8 Investment Programme

The investment programme of the Project has been made on the basis of the implementation schedule. The cost breakdown set out in Table 21.8.1 has been allocated to engineering services and construction works as follows;

Table 21.8.1 Allocation of Costs

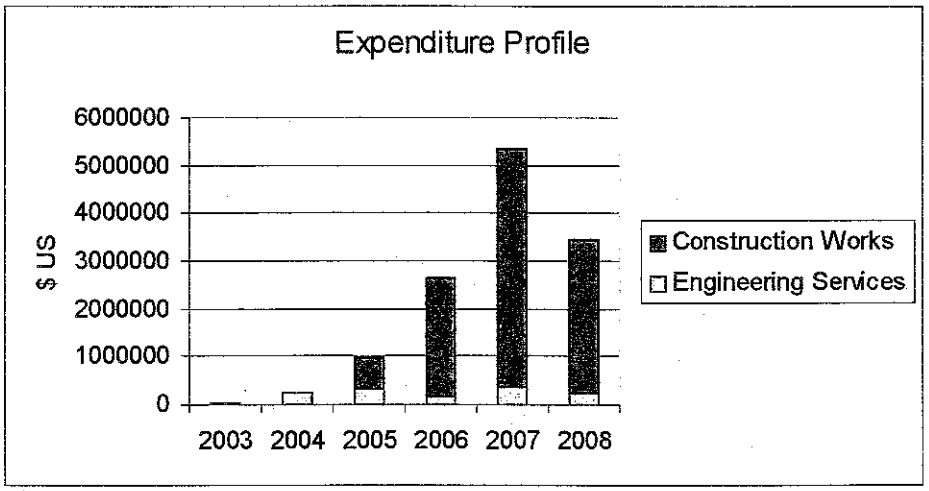
Component	*Allocation*
Engineering works	Construction works
Design	Engineering Services
Construction Supervision	Engineering Services
Client Costs	Construction Works
Transport of materials	Construction works
Contingency	Construction Works

Table 21.8.2 shows the tentative investment programme for the proposed disaster spots and structural strengthening projects. Figure 21.8.2 shows the resultant expenditure profile.

Table 21.8.2 Potential Expenditure Profile for Disaster Prevention Measures
($US, 2002 prices)

Year	*Engineering Services*	*Construction Works*	*Total*
2003	30,918	-	30,918
2004	235,330	-	235,330
2005	293,840	672,110	965,950
2006	166,100	2,466,136	2,632,236
2007	341,803	5,042,143	5,383,945
2008	220,491	3,248,117	3,468,608
Total	1,288,482	11,428,506	12,716,988

Source : Allocation of Capital Costs (Table 20.3.3) to Implementation Schedule (Figure 21.7.1)



Source : Table 21.8.2

Figure 21.8.1 Potential Expenditure Profile for Disaster Prevention Measures

21.9 Financing Arrangements

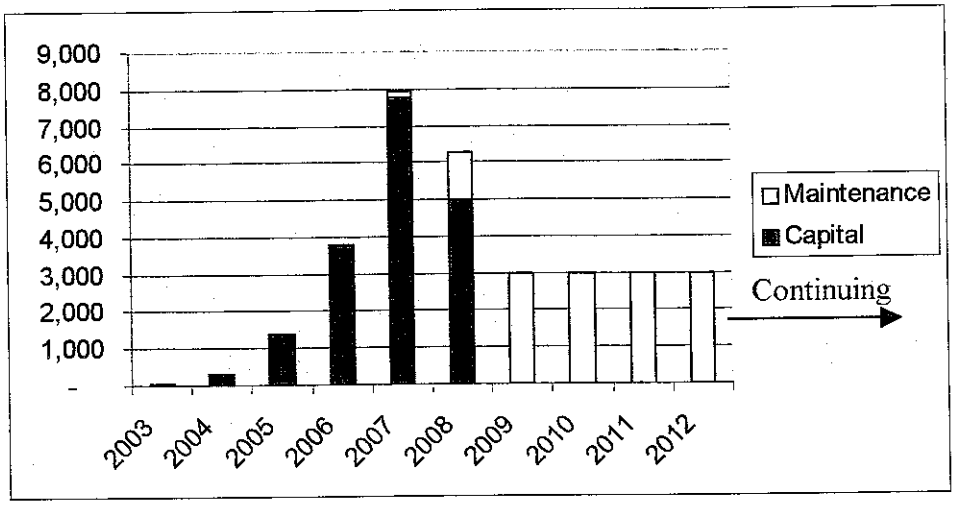
This report has underlined the importance of disaster prevention measures to Nicaragua. As a result, it is anticipated that the necessary works can be funded by an International Donor, and the proposed implementation plan provides for the processing of an appropriate grant application. Typically, in Nicaragua grant aided highway projects are co-financed by the Government of Nicaragua at an average rate of 10% of the total project cost. It is assumed that this can apply to the capital expenditure of this project, and the Government assumes full responsibility for the subsequent maintenance of the disaster prevention measures.

It is therefore recommended that MTI makes budget provision for the implementation and maintenance of this project in accordance with Table 21.9.1 and Figure 21.9.1.

Table 21.9.1 Proposed MTI Budget Provision for Implementation and Maintenance of Disaster Prevention Measures ('000s Cordoba)

Year	Capital	Maintenance
2003	45	-
2004	339	-
2005	1,391	-
2006	3,790	-
2007	7,753	165
2008	4,995	1,301
2009	-	2,984
2010	-	2,984
2011	-	2,984
2012	-	2,984

Source : Capital budget 10% of total of Table 21.8.1, Maintenance Budget as Table 21.4.1, both converted at $1 = 14.4 Cordoba



Source : Table 21.9.1

Figure 21.9.1 Proposed MTI Budget Provision for Implementation and Maintenance of Disaster Prevention Measures ('000s Cordoba)

CHAPTER 22

MANAGEMENT SYSTEM AND OPERATION

CHAPTER 22 MAINTENANCE AND OPERATIONS SYSTEM

22.1 General

Management and operation work differs in times of disaster and in routine/periodic maintenance. Therefore, these are examined as two separate items.

22.2 Method for Establishing Maintenance Program

22.2.1 General Flow of Maintenance and Operations System

Taking into consideration the present status of road maintenance in MTI, an overall concept for a system of road maintenance and operations is proposed as shown in Figure 22.1.1.

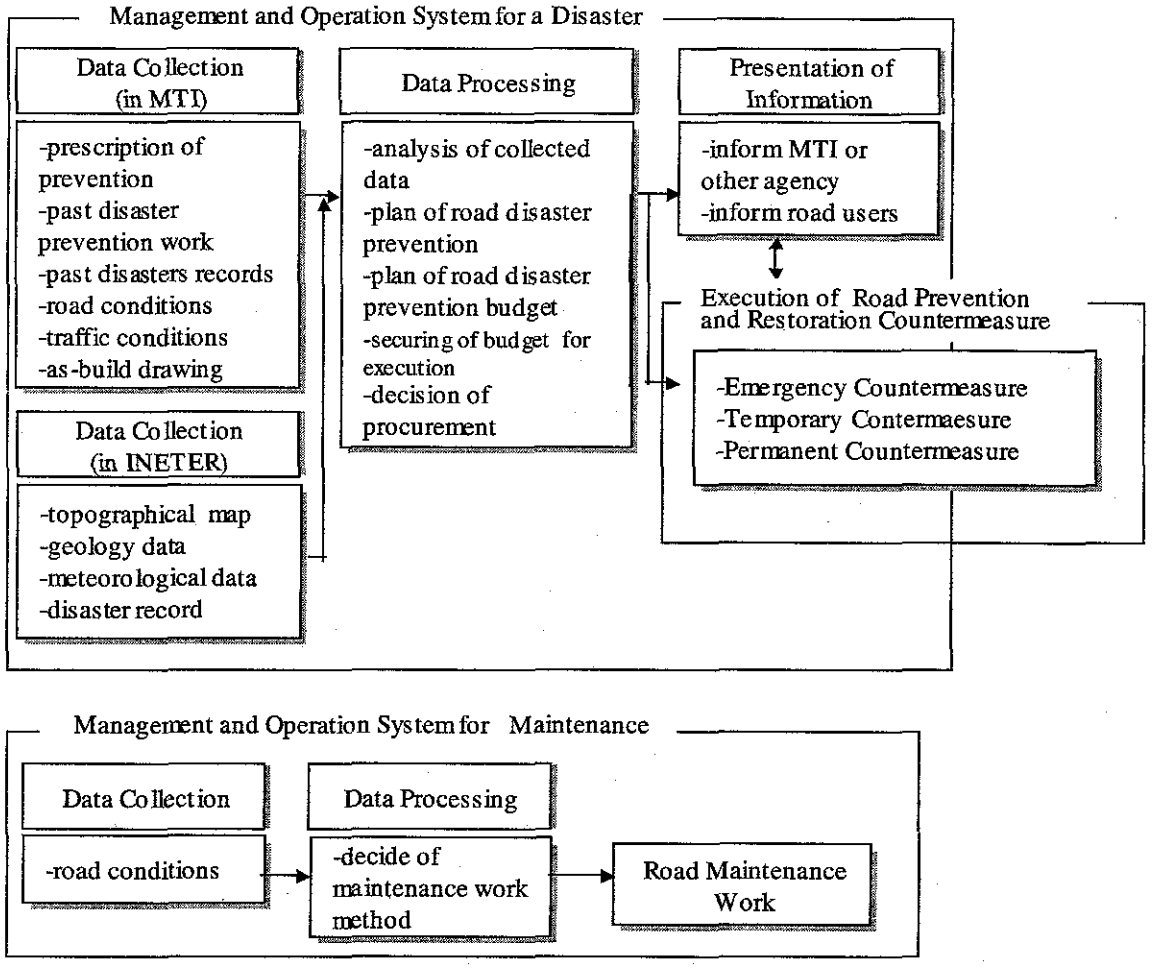


Figure22.2.1 Concept of Maintenance and Operations System

In a disaster, management and operations work can be classified into the following four types:

- Data collection

- Data processing
- Presentation of information
- Execution of road disaster prevention and road restoration countermeasures

Road disaster prevention and restoration countermeasures are classified into emergency, temporary, and permanent countermeasures. The tasks composing the above four work types are described below.

1) Data Collection

- Past disaster prevention methodologies and at-built drawings

- Records of past disasters
- Road and traffic conditions
- Data from other agencies (especially INETEL and MARENA)
- Topographical maps, geological data, meteorological data, disaster records

2) Data Processing

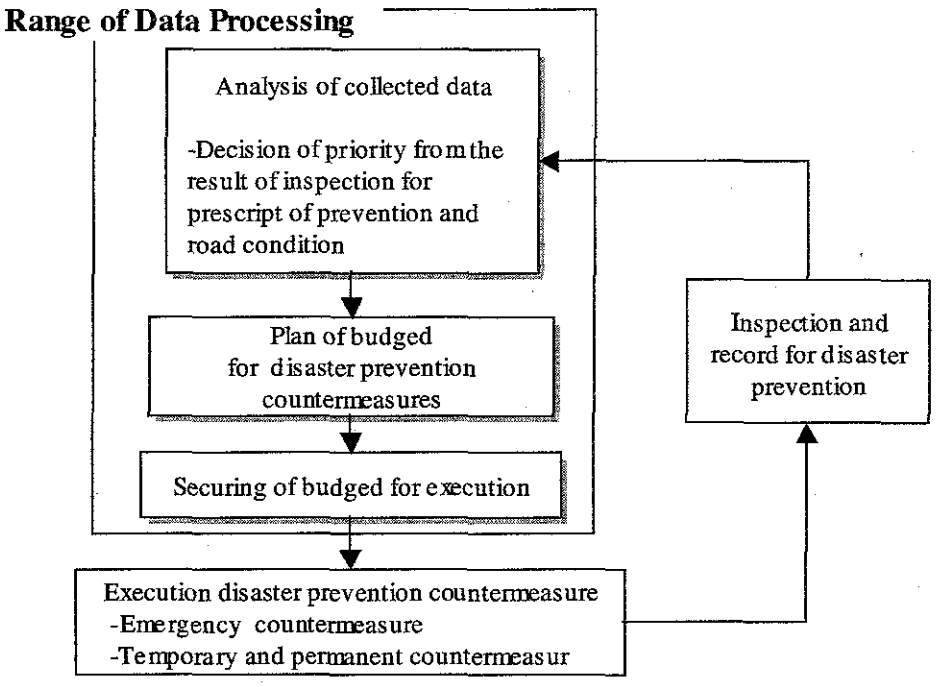


Figure 22.2.2 Method of Data Processing

3) Presentation of Information

- Transmit information on execution of countermeasures (e.g., route closure) to related agencies such as cities, towns, and the local police department.
- Inform road users of road conditions and route closures resulting from countermeasure execution.

4) Execution of Road Disaster Prevention and Road Restoration Countermeasures

- Road disaster prevention and road restoration countermeasures are executed based on the results from the data processing stage.
- Road disaster prevention and road restoration countermeasures are classified into emergency , temporary, and permanent countermeasures.
- As-built drawings are stored in a database.

22.3 Organization of Maintenance Division

1) Present Status of General Division of Roads

The General Division of Roads (GDR) is comprised of five departments: 1) Department of Road Construction, 2) Department of Road Maintenance, 3) Department of Road Management, 4) WB Affairs Department, and 5) IDB Affairs Department. Although the Department of Road Maintenance (DORM) is in charge of all aspects of maintenance work, most of the work carried out consists of road surface restoration.

As for when there is damage to road structure, road users and/or local authorities report directly to a Disaster Prevention Technical Unit that comes directly under the MTI, which then reports to the Minister. However, together with many other outstanding issues, GDR receives information too late under this system, resulting in materials and manpower to deal with a disaster being slow and behind schedule. Moreover, as for road inspections in local areas, road inspectors have to be dispatched from the head office, who then return to said office to study the field results and draw up the appropriate response. Given this background, there is insufficient planning overall, an insufficient budget, and a lack of technical capability in the GDR to deal with road disasters. Furthermore, problems continue to pile up as a result of this situation.

2) The Role of GDR

In order to firmly carry out road disaster prevention, it is important for the DORM to plan on how to acquire the necessary information and technologies, to draw up annual plans indicating locations requiring road disaster prevention, to secure a sufficient budget, to plan inspections, to store data, etc., and to report regularly to the GDR.

3) The Role of Local Offices

In order to realize effective road inspections and maintenance, it is proposed that consideration be given to having the responsibility for this work be moved from the head office to the local offices to reduce costs, as well as establishing local offices. The role of local offices is to carry out inspections for their respective jurisdictions, to compile data from their fieldwork, to keep records of disasters, to keep the head office well informed, etc.

In order for the above to be executed without fail, the four personnel described below should be assigned to local offices for road disaster prevention purposes. However, other road maintenance experts can also be assigned to these offices.

- Director: 1 (engineer)
- Engineer: 1 (to establish and confirm locations requiring disaster prevention measures)
- Technicians: 2 (to transport inspection tools and assist the engineer)

Further, it is recommended that local offices be established in the following major cities: Managua, Leon, Matagalpa, Ocotal, Granada, and Juigalpa.

4) The Role of the General Division of Planning

The role of the General Division of Planning is to secure the budget for road disaster prevention, establish an investment plan for this, and to carry out the said plan.

The organizational chart and role of the DORM in MTI to be involved with future road prevention countermeasures is as shown in Figure 22.3.1.

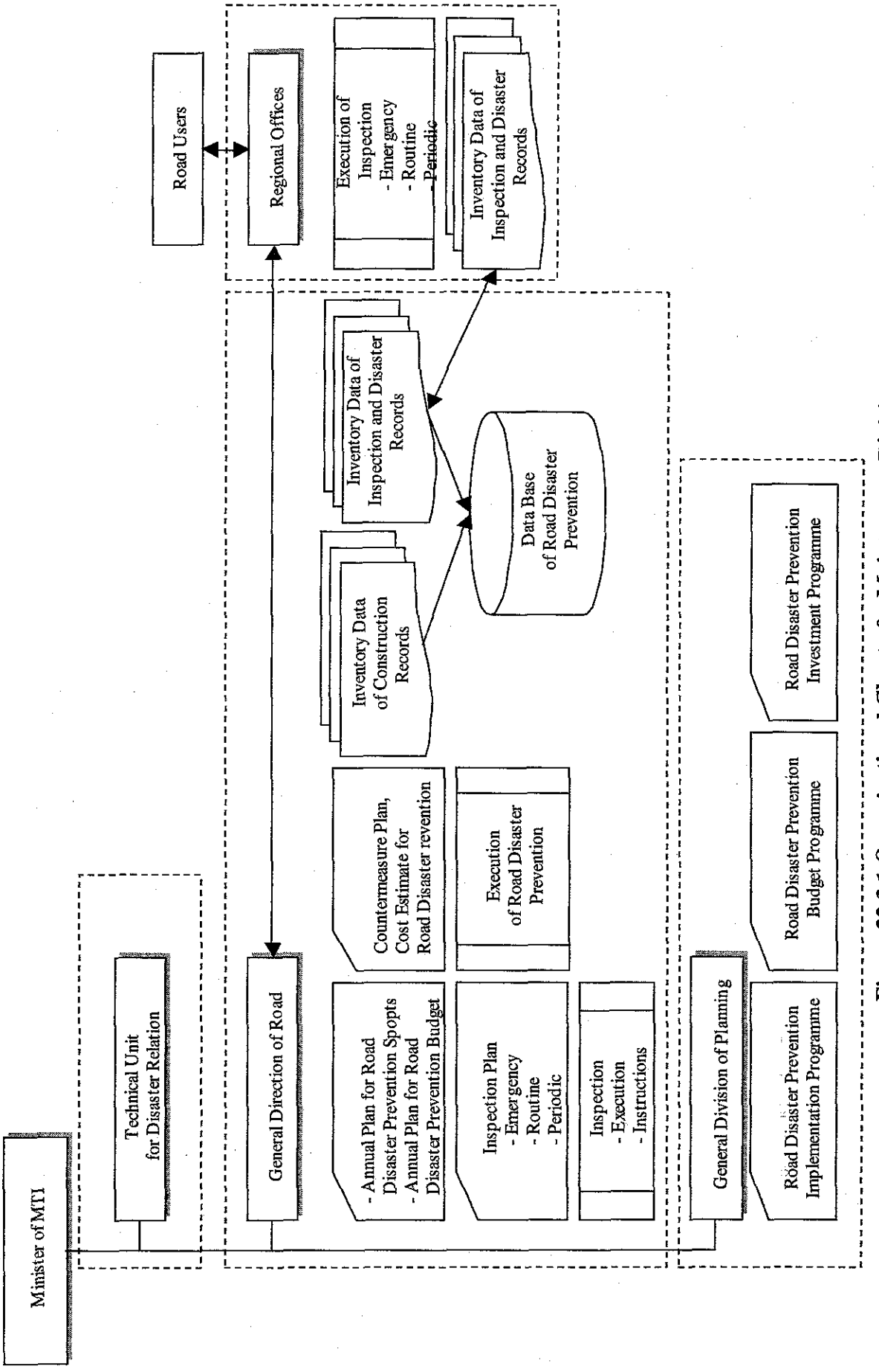


Figure 22.3.1 Organizational Chart of Maintenance Division

22.4 Inspection and Maintenance Work Methods

22.4.1 General

When maintenance work is carried out, it is necessary to consider the road facilities (e.g., slopes and bridges), social impacts, etc. of each road. For example, the status of slope and bridge facilities of a road section would be assessed via on-site inspection and maintenance work executed based on the information obtained. Note that it is necessary to always maintain road facilities in good condition to prevent disasters from happening beforehand. In addition road facilities, such as slopes and bridges become more vulnerable as they age and are more likely to fail or sustain damage when being used.

Finally, it is important to understand that insufficient maintenance not only affects road facilities such as slopes and bridges, which in turn can affect the flow of road traffic, but can also threaten life and property should they collapse, resulting in large costs being incurred for restoration, etc.

22.4.2 Types of Maintenance Inspection

Maintenance inspection consists of the following types:

- Routine inspection
- Periodic inspection
- Urgent inspection

Below, the purpose of each of these types of inspection is explained.

1) Routine Inspection

The purpose of routine inspection is to detect at an early stage minor damage and the potential for such damage to become more severe. Routine inspection consists of a visual check from a patrol car. Routine inspection is assumed to be once per week, but it is appropriate to increase or decrease inspection frequency depending on the status of road facilities (e.g., slopes, bridges, traffic volume, social environment). The main work items in a routine inspection are as follows:

- Confirmation of smooth traffic flows
- Checking for rock and/or debris on roads.
- Inspection of the status of road structures, slopes, and drainage facilities. If damage and/or abnormalities are detected, execution of more detailed inspection and recording and reporting of results.
- In case of emergency, execution of urgent countermeasures.

The potential defects for each inspection item in a routine inspection are shown in Table22.4.1.

Table 22.4.1 Inspection and Record Items

Inspection Item	Potential Defect
Carriageway	-existence of rock and debris
Shoulder	-cracking -additional new cracking
Drainage Facility	-existence of rock and debris
Slope	-rock falling or collapsing and land slides -conceive, cracking -weathering, gully erosion -existence of seepage or underground water -transformation, cracking and collapsing of cribwork, retaining wall, and shotcrete -damage and corrosion to steel materials -outflow of backfill - loosening of net and rope - withering of vegetation
Bridge	-scouring -transformation and collapsing of revetment -outflow of backfill - transformation and collapsing of abutment and pier -change in river channel -river deposits

2) Periodic Inspection

The purpose of periodic inspection is to inspect defects or potential defects of slopes, bridges, etc. close up and in detail. Periodic inspection is assumed to be once per year, but it is appropriate to increase or decrease inspection frequency depending on the status of road facilities (e.g., slopes, bridges, traffic volume, social environment). The main work items in a periodic inspection are as follows:

- Inspection of slope stability, damage to road facilities, level of damage and/or deterioration
- Check for seepage water from slopes and inspection of drainage system during rainy season to confirm functionality.
- Recording of results in a database.
- Decision on whether or not it is necessary to have further inspection by an engineer, technician, or specialist.

3) Urgent Inspection

The purpose of urgent inspection is to check for damage that poses a danger to road users and the surrounding community after the a natural disaster, such as a hurricane or

earthquake, or when existing damage threatens to become a danger. It is executed usually as a supplement to a routine or periodic inspection. The main work items in an urgent inspection are described below.

- More than one expert should do thorough detailed inspections simultaneously.
- Sketches indicating the locations, direction, and widths of cracks, together with present condition photographs and crack distribution charts, should be drawn up. Moreover, measurements should be performed if needed and topographical maps, cross-section sketches, etc. drawn up.
- Urgent inspections should be carried out rapidly after a disaster such as a rainstorm, hurricane, earthquake, etc., since road facilities such as slopes can be easily damaged in such circumstances. Should damage be detected, appropriate measures should be carried out.
- When symptoms of deformation appear, a partial or full detailed inspection of the object facility should be executed. Measurement equipment, such as an extensometer and inclinometer to check for soil movements and the progress of cracking, should be used.
- If soil movement is ongoing, it should be carefully monitored. It is assumed to be material of the stability judgment. From the result of materials, the part with the possibility of the occurrence of the disaster is separately inspected in detail. Strengthening of the countermeasure and observation is examined.
- When slope damage, landslides, etc. occur, boring should be carried out in order to ascertain present conditions. That is, boring should provide data to investigate the direction of soil movement, the existence of slide surface groundwater, soil composition, etc.

The workflow for maintenance management is as shown in Figure 22.2.1.

4) Inspection System

As described above, by executing inspections that are purpose oriented, it is possible to avoid a road disaster from occurring. For this reason, the following inspection team system is recommended:

- Total no. of members per inspection team: 3
- No. of engineers: 1 (to establish and confirm locations requiring disaster prevention measures)
- No. of technicians: 2 (to transport inspection equipment and assist engineer)

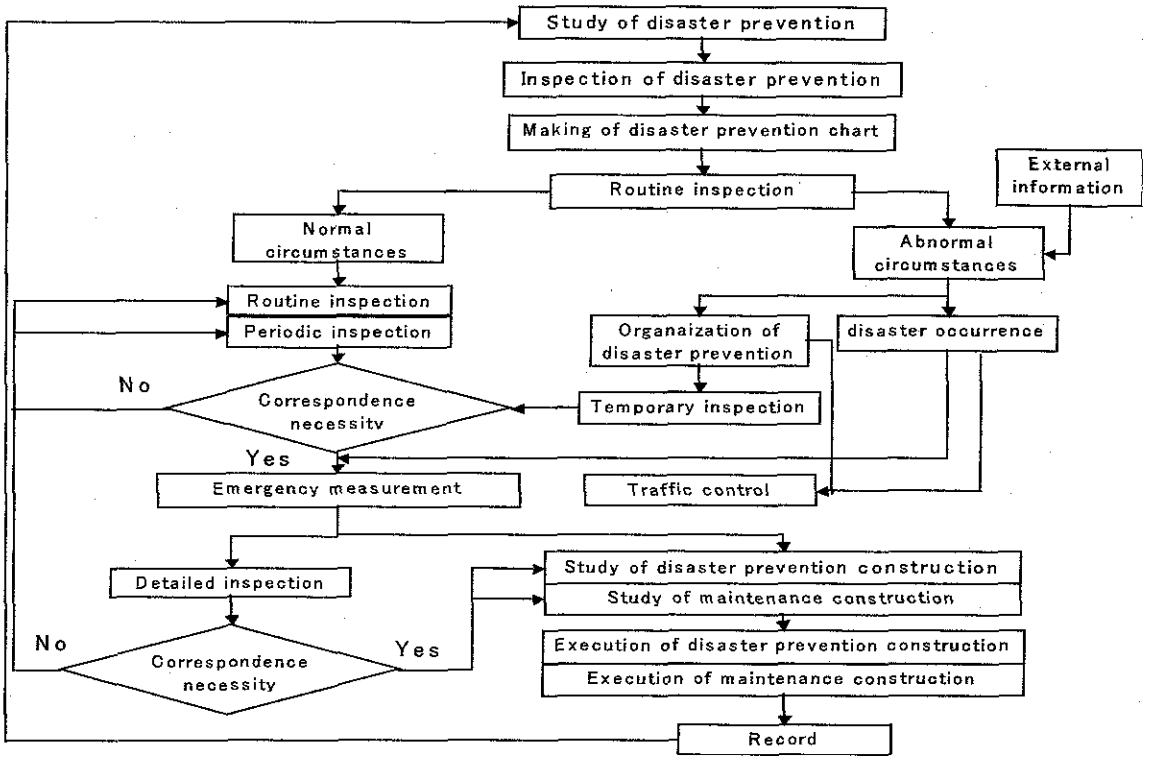


Figure 22.2.1 Flow Chart for Maintenance Management

22.4.3 Methods of Repair/ Rehabilitation

1) Priority Work Items

Priority work items for repair and rehabilitation are listed below.

- The secondary disaster prevention gives priority after confirmation of dread of secondary disaster and work safety.
- Confirmation of detour road.
- Confirmation of appropriate amount of repair and rehabilitation work.
- Selection of appropriate repair and rehabilitation methods taking into consideration availability of materials.
- In determining the cause of road facility deformation or collapse, various inventory data are used.

2) Types of Repair and Rehabilitation Methods

a) Cracking on Slopes

The selection of the method of repair and rehabilitation is as shown in Figure 22.4.2.

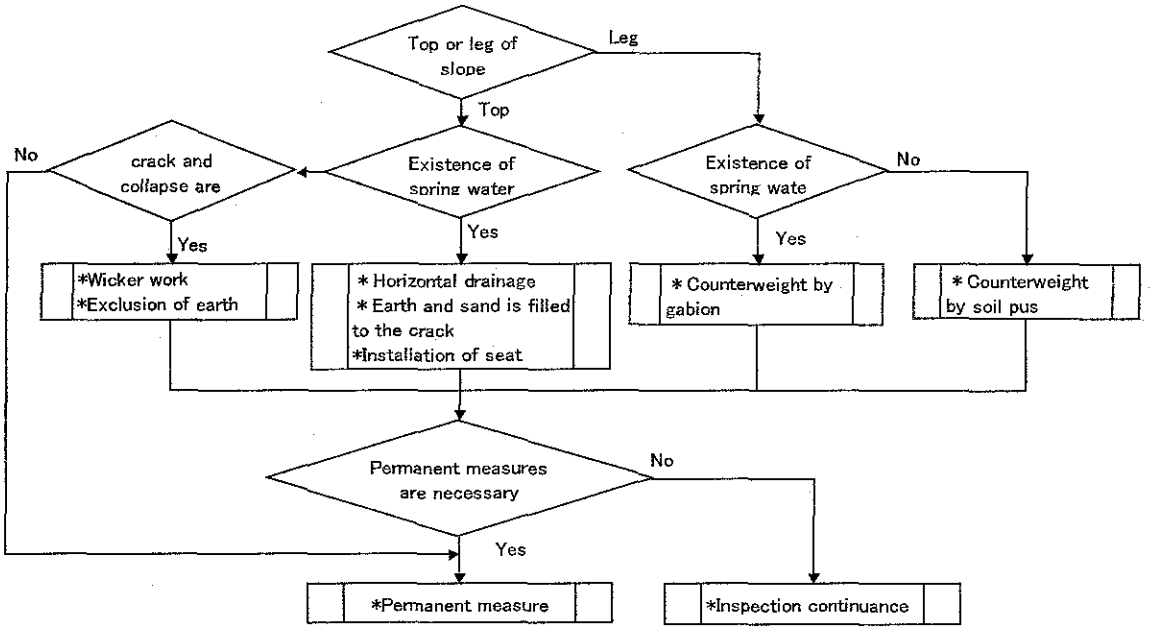


Figure 22.4.2 Method of Repair/ Rehabilitation of Crack and Damage on Slope

b) Boulder Stone and Loose Stones on Slopes

The selection of the method of repair and rehabilitation is shown in Figure 22.4.3.

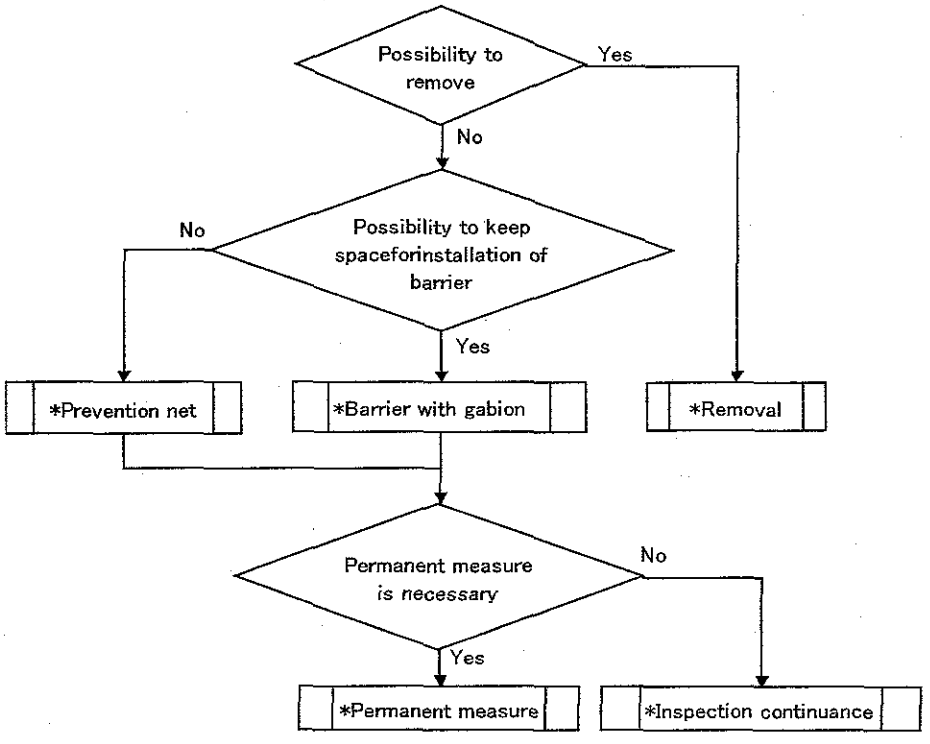


Figure 22.4.3 Method of Repair/ Rehabilitation of Boulder Stone and Unfixed Stone on Slope

c) Defect in Drainage Facility and Weathering of Shotcrete

The selection of the method of repair and rehabilitation is shown in Figure 22.4.4.

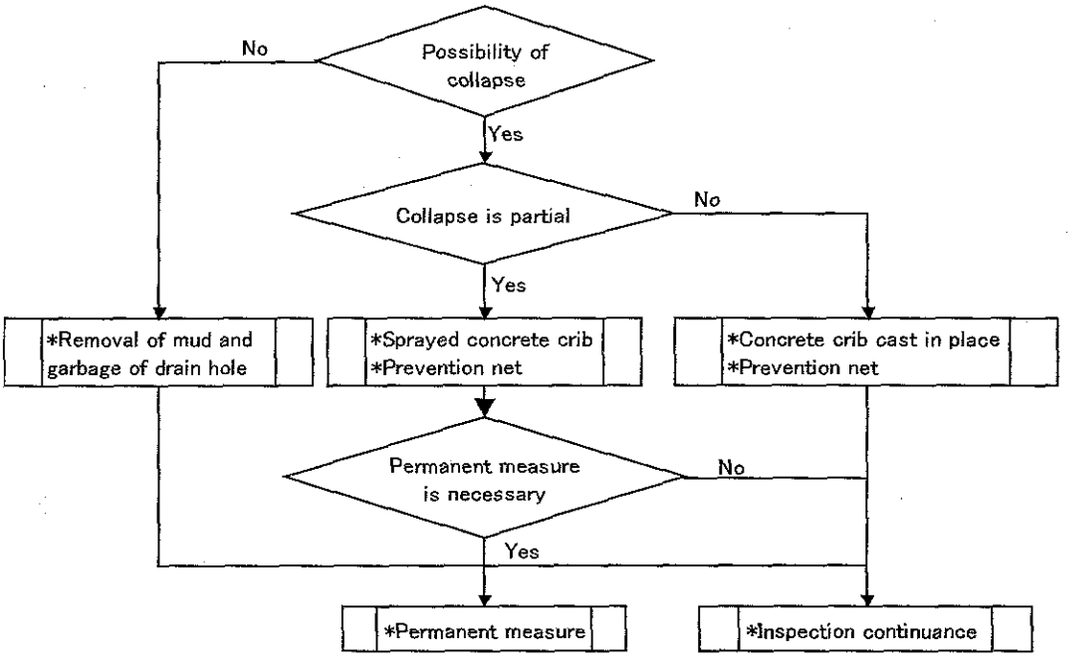


Figure 22.4.4 Method of Repair/ Rehabilitation of Defects in Drainage Facility and Weathering of Shotcrete

d) Slope Damage from Road Surface Water Inflows

The selection of the method of repair and rehabilitation is shown in Figure 22.4.5.

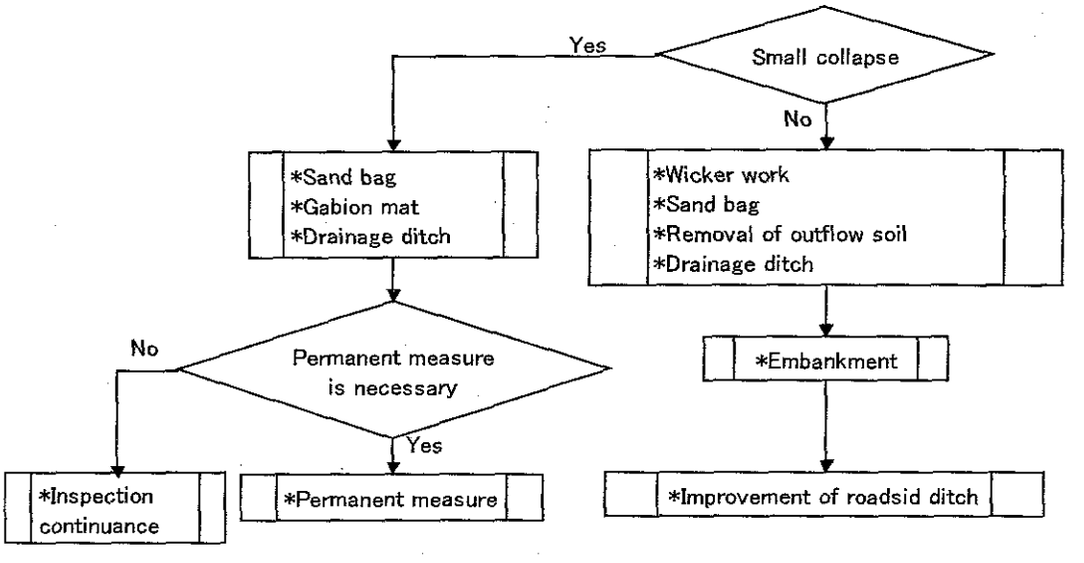


Figure 22.4.5 Method of Repair/ Rehabilitation of Slope Damage from Road Surface Water Inflows

e) Landslide

The selection of the method of repair and rehabilitation is shown in Figure 22.4.6.

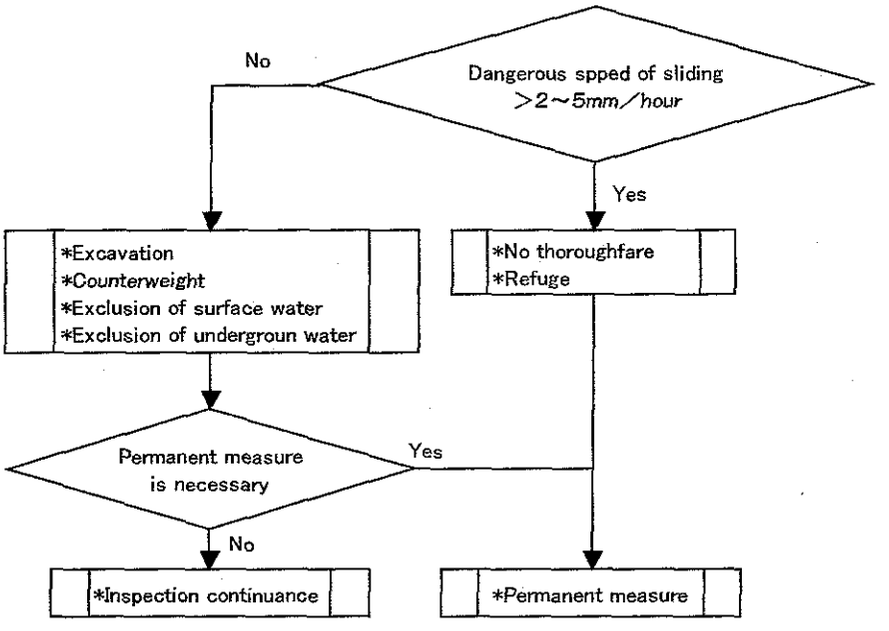


Figure 22.4.6 Method of Repair/ Rehabilitation of Damage from Landslides

22.5 Procurement

The main types of equipment and materials for disaster prevention countermeasures that could be procured in Nicaragua were examined in Chapter 7. Chapter 18 described the actual quantities of materials and the equipment needed for the different countermeasures. As for the selection of the type of maintenance work method, this was described in the preceding sections of this chapter (special materials werenot considered). Based on the above work, the Study team was able to confirm that all of the materials for the countermeasures could be procured in Nicaragua. As for equipment, everything could be procured except for a shotcrete machine.

(Note that when material is obtained from quarry sites, it is necessary to observe the Law No387 concerning mining).

As for contractual matters when the countermeasure are executed, two cases are considered. The first case is contracting with a private company and the second case with COERCO (or a public entity). The selection of the contract type is to be decided by MTI and will depend on the amount of construction work required.

22.6 Plan of Database System

It is important that the maintenance records, the facility conditions, condition of geological and weather characteristics are grasped in order to achieve the effective road maintenance. And several relative data, which are geology, topography and hydrology, should be arranged to use smoothly. Therefore the various database should be established promptly.

All of the data collected in this Study should be used for near future. The database of road maintenance in MTI is recommended as shown in Figure 22.6.1. The arranged data are as follows;

- Basic data (route number, distance, coordinates, type of structure, photographs),
- Survey records (topography, geology, weather, hydrology, traffic volume, socio-economic index, etc.),
- Facility, road inventory,
- Construction records (as-built drawings, qualities, applied standards, construction method, etc.),
- Inspection frequency, inspection schedule, and
- Repair/ restoration records and its schedule.

The Bridge Management System (BMS), which was donated to the General Direction of Roads by DANIDA in October 2001, is operated and managed efficiently now. Therefore, in the future, this plan of database system should be managed in cooperation with BMS.

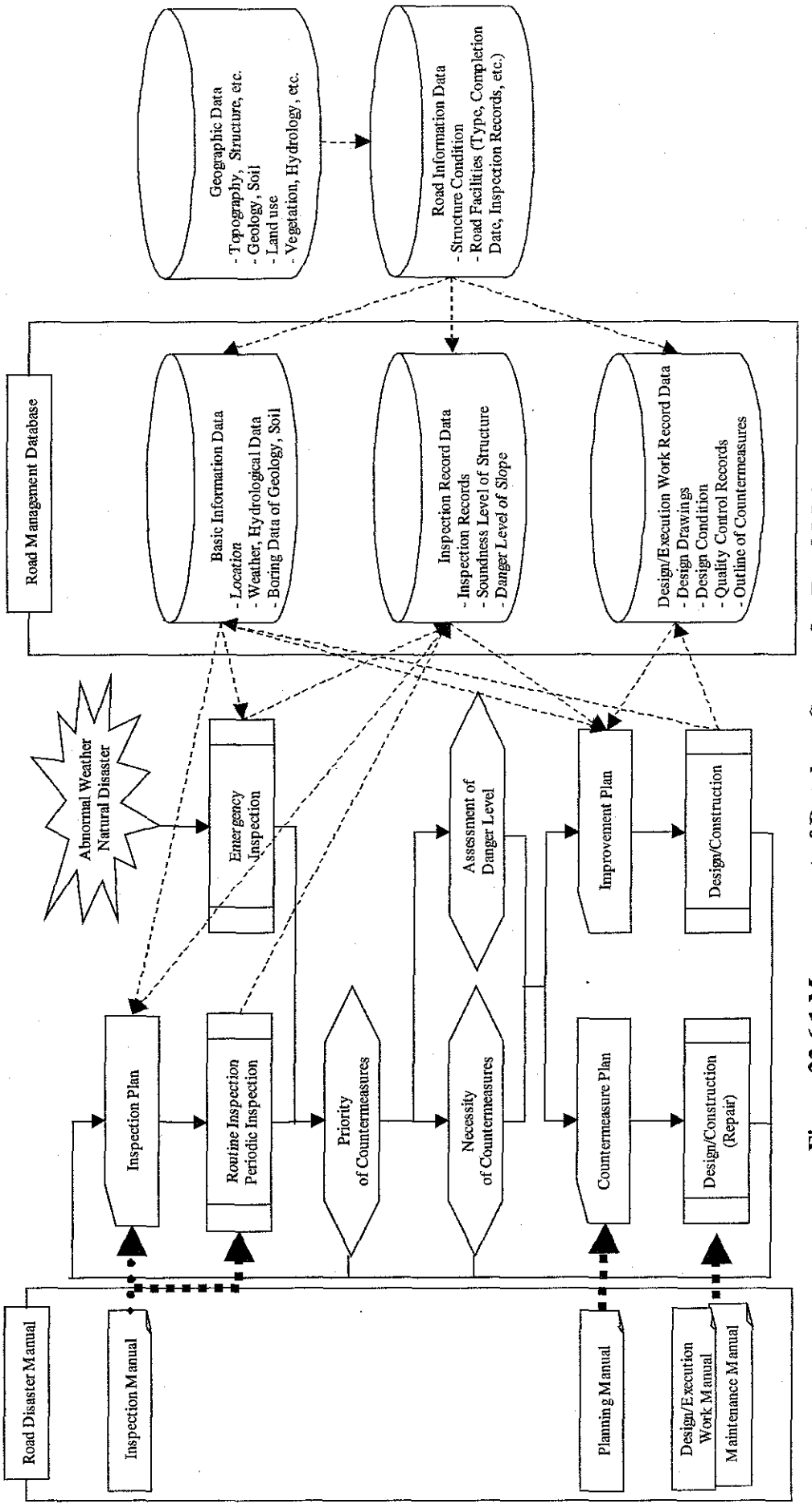


Figure 22.6.1 Management of Database System for Road Maintenance

CHAPTER 23

CONCLUSION AND RECOMMENDATION

CHAPTER 23 CONCLUSION AND RECOMMENDATION

The feasibility study proved that project spots of Package 1, 2 and 3 are technically, environmentally and economically feasible. The information and data surveyed in this Study can be finally concluded as follows.

23.1 Early execution of the disaster prevention spots

The identified disaster prevention spots are highly critical. Therefore, the disaster prevention work should be executed as early as possible in order to protect the safety of road users and the stability of traffic movement and the economy.

Therefore, the priority order of the project package should be considered as grouped in the following Table 23.1.1.

Table 23.1.1 Priority Order of Project Packages

Priority Order	Package No.	Road No.	ID No.	Countermeasure	Total
1	1	Nic.1	N001AA280	Horizontal drainage	7
			Junquillal	Gabion mat	
			San Nicolás	Gabion mat	
			San Ramón	Gabion mat	
			N001A240	Removal of loose rocks, installation of netting	
			N001B230	Removal of loose rocks, installation of netting	
			N001B150	Cutting, shotcrete and drainage	
		NIC.3	N003B400	Cutting and drainage	2
			N003B320	Retaining wall and fill, drainage and re-vegetation	
		NIC.26	N026B160	Removal of loose rocks, Installation of netting and drainage	3
			San Juan de Dios	Gabion mat	
			Papalón	Gabion mat and riprap with mortar	
2	2	NIC1	N001A290	Removal of loose rocks, Installation of netting and drainage	1
		NIC.3	N003B370	Cutting and drainage	3
			El Guayacán	New bridge	
			N003E170	Cutting and drainage, Concrete dam and Box culvert	
		NIC.5	N005A010	Cutting and drainage	1
		NIC.26	La Banderita	Masonry wall and gabion mat	2
			Solis	Gabion mat and riprap with mortar	
3	3	NIC.1	Las Chanillas	Concrete brocks	5
			N001B170	Cutting and drainage	
			N001B120	Cutting and drainage	
			Rio Inali	Gabion mat and stone masonry	
			Rio Tapascali	Gabion mat	
		NIC.3	N003C230	Cutting and concrete protect with vegetation, Lower down embankment with drainage	3
			N003C150	Cutting and drainage above road, embankment, Vegetation and drainage below	
			N003C140	Cutting with drainage and horizontal drainage above road, embankment, vegetation and drainage below	
		NIC.26	N026A060	Cutting, shotcrete and drainage	3
			N026B140	Cutting, drainage and horizontal drainage	
			N026A150	Cutting and drainage, lateral carriageway drainage	
Total Disaster Prevention Sites					30

23.2 Recommendation

In order to execute the projects, the MTI has been recommended to take the following actions.

- **Execution of Screening, Emergency/ Routine/ Periodic Inspection Survey,**

  Approximately 80 over disaster potential spots were identified by the inspection survey on the objective six (6) roads, which are NIC.1, NIC.3, NIC.5, NIC.15, NIC.24 and NIC.26, in this Study. The screening and inspection surveys should be carried out for not only the objective roads but also other major roads and the rural roads.

- **Understanding Manuals and Standard Drawings,**

  The manuals are composed of five (5) parts as below.

  - An Inspection Manual,
  - A Planning Manual,
  - A Design/ Execution Works Manual,
  - A Maintenance Manual, and
  - A Design Standards/ Standard Drawings.

  Each manual is applicable to conditions on Nicaraguan roads, and users must understand the contents of all 5 manuals.

- **Strengthening of Maintenance Division in MTI,**

  The Direction of Road Maintenance is organized in General Division of Roads of MTI. However, its main work is only minor maintenance works of road surfaces on major roads. Almost all of major maintenance works are carried out by donations from the foreign counties.

  In order to build up a strong maintenance organization, the following actions are recommended.

  - Clarification of roles and responsibilities in the range of Direction and Division with a role in road maintenance,
  - Establishment/ management of Database for the maintenance work, and
  - Reorganization of reporting and liaison lines.

- **Establishment of Regional Offices, and**

  In order to get information of disaster quickly, regional offices should be established at main towns on major roads. The roles of regional offices will be to carry out screening, and other inspection surveys for emergency, routine and periodic maintenance. Data collected from inspection surveys should be analysed in regional offices and be reported to the main maintenance division in MTI. Thus

main maintenance division in MTI. Thus the regional offices should take responsibility for major roads in their local areas.

- **Secure the Special Budget for Road Disasters**

  A special budget for roads disaster should be established to a safeguard against possible loss. MTI should take on great responsibility for the management and control of major and rural roads in Nicaragua. If traffic accidents occur within MTI's responsibility, it is likely to be a result of very bad carriageway surfaces, very dangerous slope surfaces, very risky bridge condition, etc.

  Therefore, in order to safeguard road safety and economic development to the road users, MTI should itself secure a special budget for road disasters.

APPENDICES- PART A

Appendix A1: Stability Survey Sheet (Chapter 4)

Appendix A2: Type of Countermeasures (Chapter 7)

Appendix A3: Hydrological Data (Chapter 8)

Appendix A4: Data for AHP (Chapter 14)

Appendix A1

Stability Survey Sheet (Chapter 4)

A1.1 Table of the Inspection Result

A1.2 The Figure of Inspection Points

A1.3 Record by Inspection Site

A1.4 Stability Investigation Table

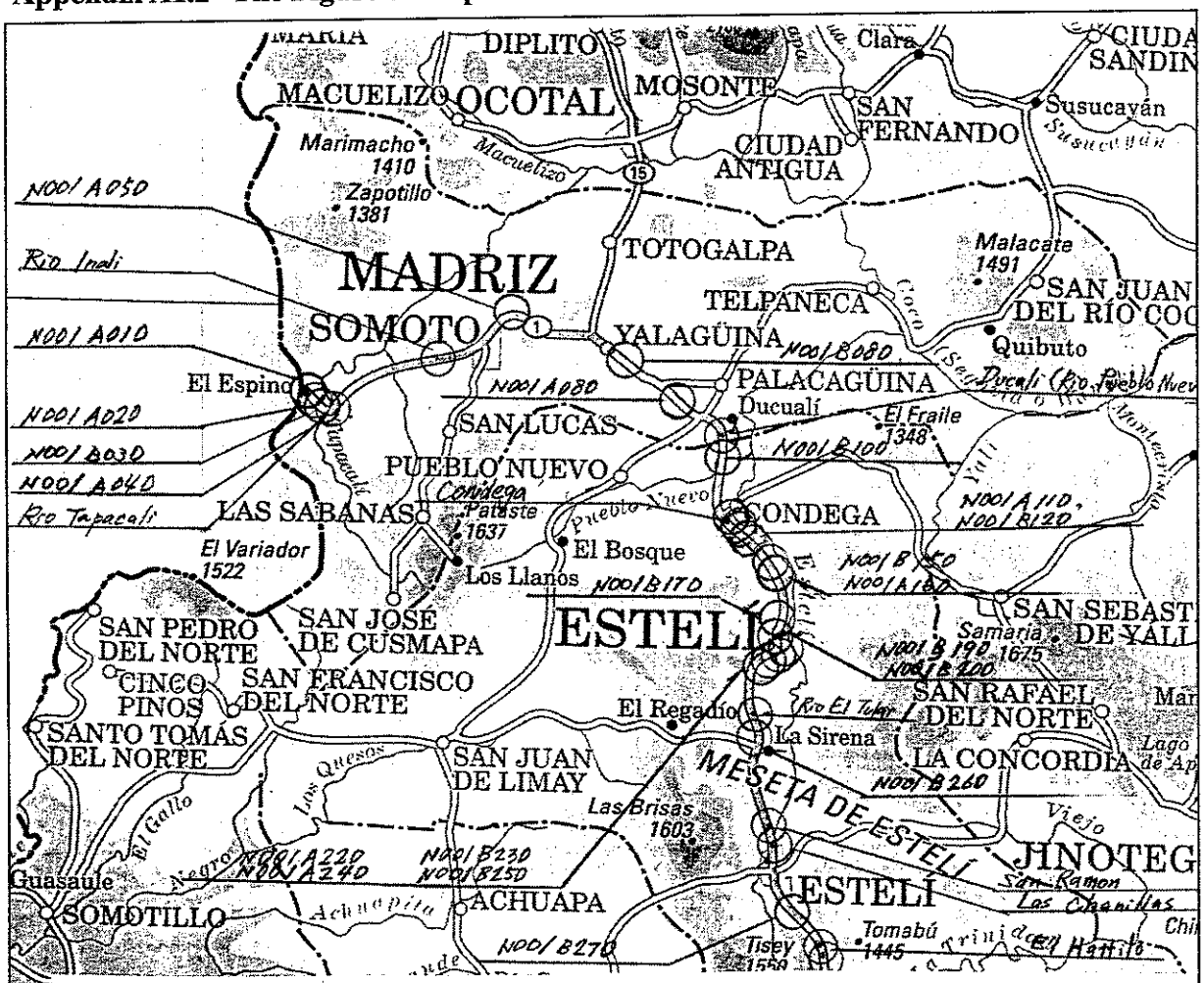
A1.5 Record of the History of Damages

Appendix A1.1 Table of the Inspection Result

Format-1

No.	Name of the Road	Road Clasification	Name of the site	Inspection Item	Vehicle crossing restriction	Restriction Criteria (mm.)		Deviation	Inspection Result of year XX (Range:)	History of dissasters (After the year XX)	Inspection Result of year 2002			Proposed Threatment Work				Stability in case of shake (Rock Falling, Collapse)
					Yes:Transit ·1	Continuous Precipitation	Precipitation per hour	There is ·1		There is disaster record ·1	Evaluation Grade	Integral Evaluation	It is neccesary to take measures ·1	Type of Work	Norm	Quantity	Preliminary costs	Stable 1
					Yes:Special ·2			There is not ·2		Presence of dissaster traces ·2			Prevention Prescription ·2					Unstable 2
					No ·3			Others ·3		There is not history of dissasters ·3			It is not neccesary to take measures ·3					
																		N/A

Appendix A1.2 The Figure of Inspection Points



The Figure of Inspection Point

LEGEND

Route No. N001 | Inspection Item A | Serial No of site 300 | Integral Evaluation (1)

Nic1=N001 A=Rock fall 300=No.30 (1) = It is necessary contermeasure

	Inspection Item	Code
1	Rock fall & Collapse	: A
2	Rock collapsing	: B
3	Slope slide	: C
4	Debris flow	: E
5	Embankment	: F
6	Wall	: G
7	Scoring for the Bridge	: H
8	Others	: J

Mark	Detail
O	: 2002 Inspection site
△	: Former Inspection site
×	: The site where have damage History

Integral Evaluation	Comment
(1)	: It is necessary to take measures
(2)	: Response, making prescription of Prevention
(3)	: It is not necessary to take measures

* In case of b r i d g e s investigation, Bridge name and Station No. are adopted as Code

Appendix A1.3 Retord by Inspection Site (1/2: Slope Failure)

Format-3-1

No.			Inspection Item		Name of the road		Kilometer post (of)		(to)		From Managua / To				Total m.		
Clasification	Toll / Common	Category		Name of the site			Site mark		Latitude				Longitude				
Traffic Restriction	Yes (Crossing/Special) Not		Restriction Criteria		Traffic Volume	Day of the week	Holliday		DID	Yes No	Bus Route	Yes No	Detour	Yes Not			
Pictures of the site, Sketch (to indicate the location of the existimg works and the site mark)							Location map (scale 1/50,000)										
Special remarks: Inspection Date: / / (Weather: clear・cloudy・rain) Method of inspection: Note:							Disasters history	Yes (1. See damage record, 2. unknow details:) Not									
							Other inspection objectives	Exist or Not Rock fall, collapse, rock mass collapse, land slide, debris flow, embakment, retention wall, bridge, others									
							Inspection result of year	Score: (Completed・In execution・Not started) Countermeasure:									
							Inspection result of 2002 year	Score: Integral evaluation: 1. It's necesary to take measures: 2. Response, making prescription of prevention: 3. It's not necesary to take measures:									
							Forecast of disasters dimension										
							Proposal countermeasures	Kind of work: Norm: Quantity: Preliminary cost:									
							Stability in case of seism (for rock fall & collapse only): stable / unestable										

Appendix A1.3 Record by Inspection Site (2/2: Scouring of Bridge Foundation)

Format-3-2

No.			Inspection Item		Name of the road			Name of the bridge			Length of the bridge		m.								
Clasification	Toll / Common	Category			Site name		Name of the river	Kilometer post (of)		Latitude	(to)		From Managua / To		Longitude			Total	m.		
Tyaffic Restriction	Yes (Crossing /Special) Not		Restriction Criteria		Tyaffic volume		Day of the week			Holiyday			DID	Yes Not		Bus Route	Yes Not	Detour	Yes Not		
Location map					Plane of the bridge								Scouring condition, abnormality (Sketch) (Indicate the inspection site, scouring deep and the existent works)								
River desoription	Inclination of the river be		1/		Reason of the foundation selection 1) Using bridge plan, river plan, etc.			Position of the domineering point ( ) (Scouring situation)													
	Level of the river bed projection		m.																		
	Level of the maximum depth of the river bed		m.																		
	Blockage ratio		%																		
	Minimum span		m.																		
	Height under the girder (clearance)		m.		2) Site situation																
Bridge Description	Abut	Structure						Maximum hight of fundation (HU)	m.	River bed hight in the scouring place (HS)	m.										
		Fundation																			
	Pier	Structure			Taking in to account 1), Abut inspection			Lower height of fundation (HL)	m.	Scouring depth (DS=HU-HS)	m.										
		Fundation																			
		Width of the nier		m.	pier ( )																
Remarks													Disasters History								
Inspection date: / / (Weather: Clear・Cloudy・Rain)													Yes 1. See damage record, 2. Unknow details:) Not								
Ispection Method:													Inspection result of								
													Score: (Completed・In execution・Not ystarted) Countermeasure								
													Score ( ) Integral evaluation: 1. It's necesary to take measures: 2. Reepons making prescription of prevention: 3. It's not necesary to take measures:								
													Inspection result of 2002 year								
Note:													Forecast of the disasters prevention								
													Proposal countermeasures								
													others								

Appendix A1.4 Stability Investigation Table (1/5)

Stability Investigation Table (Rock Falling, Collapse)

Form 4-1

Inspector's Name

Item		Factor	Cut Slope: Clasification	Grades	Evaluation Grades	Natural Slope: Clasification	Grades	Evaluation Grade
Topography	Topography that contains collapse factor	G1:Talus	One corresponds to G1	3		Several correspond to G2	3	
		G2: Collapsing traces				One correspond to G2	2	
		: Nick line is clear	No correspond to G1	0		No correspond to G2	0	
		G3:Erosionable terrace lap	Several correspond to G2,3	3		Several correspondto G1,3	3	
		over hang, slope that contains water	Corresponds to G2,3	2		One correspond to G1,3	2	
		debris flow traces	No correspond to G2,3	0		No correspond to G1,3	0	
		G4:There is a ridge in the peak, over hang	Corresponds to G4		(6)	Corresponds to G4		(6)
Soil, Geology, Structure	Soil that ruins	Soil that is easily erosionable (Soil that lose resistance by absorbing water, others)	Notable	8		Notable	2	
			A little notable	4		A little notable	1	
			No correspond	0	(8)	No correspond	0	(2)
	Quality of the erodable rock	High density in cracks or fragil layer. Soft rock easily erosionable. Quality of quickly erosion.	Notable	12		Notable	8	
			A little notable	6		A little notable	4	
			No correspond	0	(12)	No correspond	0	(8)
	Collapse Structure	LAYER DIRECTION (stratification, weak line)	Correspond	8		Correspond	2	
			No correspond	0		No correspond	0	
		Soils upon impervios rocks (Hard rock in the superior area/ inferior part is soft)	Notable	6		Notable	4	
			A little notable	4		A little notable	3	
			No correspond	0	(14)	No correspond	0	(6)
Soil Surface Condition	superficial soil condition, , loosening and boulder stone		Unstable	12		Unstable	24	
			A little unstable	6		A little inestable	12	
			Stable	0		Stable	0	
	Collapsed rocks and bounder stone are unstable~ a little unstable		Correspond		(12)	Correspond		(24)
	Inflow water situation		There is inflow water	8		There is inflow water	4	
			leak out a little	4		Leak out a little	2	
			No exist	0	(8)	No exist	0	(4)
	Surface soil condition		denude soil-vegetation	5		Denude soil-vegetation(grass)	16	
			Compound (vegetation, stru	3		Compound (denude soil, grass	10	
			Structures	1	(5)	Trees	6	(16)
Shape	Inclination(i), Height	Soil: H>30m		18		Height: H>50m	10	
		Soil: H≦30, i>norma		15		Height: 30≦H<50m	8	
		Soil: i≦norma,15		10		Height: 15≦H<30m	6	
		Soil: i≦norma,15≦H<30		5		Height: H<15m	4	(10)
		Rock: H≧50m		18		Inclination: i≧70°	10	
		Rock: 30≦H<50m		16		Inclination: 45°≦i<70°	10	
		Rock: 15≦H<30m		12		Inclination: i<45°	5	(10)
		Rock: H<15m		10	(18)			
Deformation	Slope and cliff deformation (fisility, little rocks falling,scouring, piping hoe, subsidence, conceiving, tree fall, joint, open joint, work done deformation)		Several correspond,somewhat clear	12		Several correspond,somewhat clear	10	
			Correspond, Not so clear	8		Correspond, Not so clear	5	
			No exist	0	(12)	No exist	0	(10)
	Slope deformation and close cliffs. (rock falling, collapse, joint, conceiving, others)		Several correspond,somewhat clear	5		Several correspond,somewhat clear	4	
			Correspond, Not so clear	3		Correspond, Not so clear	2	
			No exist	0	(5)	No exist	0	(4)
Total			Slope: Total grade	0		Natural Slope Total grade	0	

[Treatment Works] (BI)=(AI)+α o (AI)X

Efficiency of the works done	Evaluation Grade: Slope	Cliff
Well protection of the rock falling and foreseen collapsea. Or if disasters occur, it works sufficiently.		
It protects in certain degree the rock falling and foreseen collapse. It works when disasters occur, but not		
It protects in some parts the rock falling and foreseen collapses. When disasters occur, it works somewhat.		
There is no any kind of treatment. Or if it exist, it is not working at all.		
	(B1:Slope)	(B2:cliff)

hundimiento, hinchamiento, árbol caída, grieta, grieta abierta, deformación de obras realizadas)

[History] ©

*There is no need to make history evaluation if rock falling or slope/cliff collapsing has no occurred after the realization of the threatment work.
→(C) es 0

Frequency clasification and disaster degree.	Evaluation Grade
After the recent threatment, it caused a traffic disturb. (The work done, did not operate)	
Dit not caused problems to the traffic, but there is history that big rocks and collapses reached the road. (The work was not efficient)	
There is the history that fallen rocks and collapses reached the slope lap or cliff lap. (The work done it is functioning in certain degree, but it is necessary to do a complementary work)	
	(C)

(D)=MAX(B,C)

Evaluation through the factor point	(B)=MAX(B1,B2)
Evaluation by History	C)
The highest between (B) and (C)	(D)=MAX(B,C)

[Stability in case of earthquake]

Stable	
Unstable	

*If you notice G4 of Topography and that collapsing rocks and boulder stones are unstable, you have to choose the Unstable option

[Total Evaluation]

Countermeasure	Evaluation
It is needed to take counterm	
To respond to the elaboratio	
There is no need of new countermeasures.	

Appendix A1.4 Stability Investigation Table (2/5)

Stability Investigation Table (Rock Mass Collapse)

[Factor A]

Item	Factor	Clasification	Grade	Evaluation Grade
Phenomenos, symptom	Open joint size	Big	30	
		Small	15	
		No exist	0	(30)
	Continuous horizontal joint direction	To the degradable direction	10	
		to the stable direction	5	
		No exist	0	(10)
	Small collapse, rock falling	Exist	7	
		No exist	0	(7)
Joint Condition	Hard Rock	Regular existence, distance from each one more than 1 m.	15	
		Regular existence, distance from each one less than 1 m.	11	
		Irregular	7	
		No exist	0	(15)
	Soft Rock	Regular existence, distance from each one more than 1 m.	11	
		Regular existence, distance from each one less than 1 m.	7	
		Irregular	4	
		No exist	0	(11)
Rock mass compositio	Superior part is hard/ inferior part is soft		7	
	Superior part is soft/ inferior part is hard		5	
	All soft		2	
	All hard		0	(7)
layer orientatio	Slidable Layer Orientation		15	
	Stable layer Orientation		5	
	No exist		0	(15)
Topagraphy	Slope and cliff inclination	Over hang	4	
		More than 60°	2	
		Less than de 60°	0	(4)
	Steepest Slope Height	More than 100m.	10	
		50∽100m.	7	
		30∽50m.	4	
		Less than 30m.	2	(10)
	Cliff Shape	Cliff of ridge shape	4	
		Cliff of talus shape	3	
		Cliff de valley shape	1	
		Cliff of ridge and valley interlude shape	0	(4)
	Nick line	Clear	7	
		irregular	4	
		Unclear	0	(7)
Ground water/ rain	Thawing, inflow water	The puddle freezed during long tieme. Or inflow water exists.	4	
		It freezes quickly. After rain, becomes water.	2	
		The puddle does not freeze.	0	(4)
	Inflow water, iced column	Inside vertical joints.	2	
		It limits horizontal layers	1	
		Almost no perceptible	0	(2)
	Total			0

Inspector's Name	
Organization	

Form 4-2

[Threatment Work] (B)=(A)+α o (A)X0

Efficiency degree in works done.	Nota(α)	Nota de evaluación
It protects well the foreseen rock mass collapse. They can protect well if dissasters occurr	X0	
It protects in certain degree the rock mass collapse. If dissaster occur, they can work, but not perfectly.	-20	
It protects in some parts the rock mass collapse. When dissasters occur, it works somewhat, but no more.	-10	
There is no any kind of treatment. Or if it exist, it is not working at all.	±0	
Total	(B)	

[Total Evaluation]

Resuesta	Evaluación
It is needed to take countermeasures	
To respond to the elaboration of the disaster prevention manu	
There is no need of new countermeasures.	

Appendix A1.4 Stability Investigation Table (3/5)

Stability Investigation Table (Slopeslide)

Form 4-3

Nombre	
Organización	

[Historial] (B)

Item	Punto de observación		Nota	Nota de evaluación
History of Slope Slide	Record of past disaster and slope slide and certain legends	Existing	100	———
		No	0	(100)
Symptom of Slope slide	Crack, upheaval, and sinking of slope	Remarkable symptom	100	
	Slope stability construction's abnormality			
	Upheaval and crack etc. of road	Negligible symptom	75	
	Small collapse (The one that measures were executed after the symptom occurs of the small collapse is assumed to be the one not adopted).	Symptom none	0	———
	Total (maximam 100) (B)			(100)

[Factor] (A)

Item		Observation point		Grade	Evaluation Grade
Soil composed by landslides		Cliff formed by landslides, plateau soil type, soft inclination soil, Countour line disorder, fluid soil through the river, etc.	Clear	30	
			A little clear	15	
			Not clear	7	(30)
Geology, etc.	Geologic Structure	Failure, grinding		18	
		volcanic alteration zone, solfataric soil		18	
		direction of layer slide		14	
		stable direction of the layer		7	
		block (Structure of Intrusive)		3	
		Others		0	(18)
	Geologic age and quality of the bedrock	Mesozoic and paleozoic layer (esquisto cristalino, sedimentary rock)		7	
		Tertiary layer (sedimentary rock)		7	
		Quaternary Layer(not solidified sediments or sedimentary rock)		3	
		Others (Volcanic rock, Ignious Rock)		0	(7)
	Inflow water	Exist (including traces)		10	
		Not exist		0	(10)
		Total (Maximum grade es 65)		(A)	

(C)=MAX(A,B)

Evaluation grade of(A) the factor	
Evaluation grade of(B) the history	
The highest between (A) y (B)	(C)=MAX(A,B)

[Threatment work] (D)=(C)+ ó (C)×0

Efficiency of existing works	Grades (a)	Evaluation
There are no works, or low efficien	±0	
Some efficiency	-30	
High efficiency	×0	
Total	(D)	

[Integral Evaluation]

Response	Evaluation
It is necesary to take measures	
Solve, preparing recipe	
It is not necesary to take measures	

Appendix A1.4 Stability Investigation Table (4/5)

Form 4-4

Stability Investigation Table (Debris Flow)

Inspector's Name	
Organization	

[Factor] (A)

Item	Factor	Clasification	Evaluation Degree	
Stream Characteristic	Surface of the basin damaged by the debris flow . Surface that has more than 15° of riverbed inclination	More than 0.50km²	10	
		More than 0.15km² less than 0.50km²	8	
		Less than 0.15km²	4	(10)
	riverbed maxim inclination	More than 40°	10	
		More than 30° less than 40°	5	
		Less than 30°	0	(10)
Cliff Characteristic	Cliff surface that has more than 30° inclination	More than 0.20km²	8	
		More than 0.08km² less than 0.20km²	6	
		Less than 0.08km²	2	(8)
	Surface filled by grass and shrubs (less than 10m. height)	More than 0.20km²	8	
		More than 0.02km² less than 0.20km²	4	
		Less than 0.02km²	0	(8)
			5	
			0	(5)
	Existence of soil works with unstable soils	Exist	5	
		No	0	(5)
	History of relative high dimension collapse	Exist	10	
		No	0	(10)
			Total (A)	0

[Countermeasures] (B)

Item, Clasification		Total of Evaluation Grades			
		More than 20°	More than 15° less than 20°	More than 10° less than 15°	Less than 10°
Efficiency degree in works done.	No exist, low	100	70	50	30
	Normal	70	50	30	10
	High	50	30	10	0 (B)
	Enough	0			

[Road Structure] C)=(B)+α

Structure	Clasification	Grade(α)	Evaluation Grade
Wide of chanel	More than 10m.	-40	
	5m～10m.	-30	
	3m～5m.	-20	
	Less than 3m.	±0	
	Less than 1m. Or in case that there are neither bridges nor box culverts	±0	
Bridge Height	1m～2m.	-5	
	2m～3m.	-15	
	3m～5m.	-30	
	More than 5m.	-40	
	Total		C)

[History] (D)

Clasification	Grade	Evaluation Grade
After the recent taken measures, debris flow caused a traffic disturb.	90	
A debris flow occurred, but did not cause traffic disturb.	40	
There is the history of debris flow occurrence	0	
		(D)

(E)=MAX(C,D)

Evaluation through the factor point	(C)
Evaluation by History	(D)
The highest between (C)	(E)=MAX(C,D)

[Total Evaluation]

Answer	Evaluation
It is needed to take countermeasures	
To respond to the elaboration of the disaster prevention manual	
There is no need of new countermeasures	

[Types of supposed damages]

Bridge Destruction	
Dragging of the Embankment	
Soil sedimentation in the road caused by overflow	

Check with a circle the type that corresponds

Appendix A1.4 Stability Investigation Table (5/5)

Stability Investigation Table (Scouring of Bridge Foundation)

[River Bed Stability and revetment]

(Usual items of abutment and Bridge Pier)

Item	Factor	Clasificación	Grade	Evaluation Grade
River Bed charasteristics and bridge Structure	River Bed Inclination (are quickly)	More than 1/100	15	
		Less than 1/100 more than 1/2	10	
		Menos de 1/250	0	
	Construction Site (Abutment and bridge pier exist in a minimun Span)	Correspond	20	
		Not correspond	0	
	Construction period	Before 1945	10	
		Between 1946~1965	5	
		After 1966	0	
	Minimum distance between feet	Less than 10m.	15	
		More than 10m less than 20m	10	
		More than 20m.	0	
	Blockage ratio	More than 7%	15	
		More than 5% less than 7%	10	
		Less than 5%	0	
	girder height	Less than 30cm.	10	
		More than 30cm less than 60cm	5	
		More than 60cm.	0	
Rectification of the frequency of the disasters occurrence	Frequency (Average)	Nota (a)	Subtotal	
	Disasters occur more than once every 10 years around the	15	Total (A) (100~0)	
	Dissasters occur more than once every 5 years in the river	10		
	Dissasters occur more than once every 10 years in the	5		
	Others	0	(15)	

(Bridge Abut [Abut investigated:A]) (B)

Item	Factor	Clasification	Grade	Evaluation Grade
Bridge abut evaluation	Distance beetwen the bridge pier and the slope up from the river dike	In 5m.	10	
		More than 5m less than 10m.	5	
		More than 10m.	0	
	Bridge abut position	The pier in the river	15	
		The river wide where it is the bridge is narrow in comparison with the up river and down river	10	
		Not correspond	0	
	Stability against scouring (Penetration deep)	Correspond	-10	
		Not correspond	0	
	Protección de orilla frente y alrededor de estribo de puente	Both dimension and height correspond	-10	
		Either dimension or height correspond (One of both)	-5	
		Not correspond	0	
		Total	(B)	(25~-20)

(Bridge Pier [Bridge Pier Investigated:P]) (C)

Item	Factor	Clasification	Grade	Evaluation Grade
Bridge pier evaluation	Bridge pier structure	pile bent	15	
		rigid frame foot	10	
	Cross Flow Water direction Angle and bridge pier	More than 20°	15	
		More than 10° less than 20°	10	
		Less than 10°	0	
	Stability against scouring (Penetration deep)	Correspond	-10	
		Not corresponf	0	
	Scouring protection works	Foundation reinforcement	-10	
		Continuos protection to the pier	-5	
		No exist	0	
		Total	(C)	(30~-20)

Form 4-5

Inspector's Name	
Organization	

[Abnormality]

(Bridge Abut [Abut investigated: A])(D)

Item	Abnormality	Clasification	Grade	Evaluation Grade
Scouring Abnormality	Scouring and abnormality in foundation of riverside protection	Big Scouring and abnormality	50	Subtotal (a) maximum 100
		Small scouring and abnormality	30	
		There is no abnormality	10	
	Abnormality of bank protection	Big scouring and abnormality	50	
		Small scouring and abnormality	30	
		There is not abnormality	10	
	Subsidence and abnormality in the point where the riverside protection and and river dike joint	Big abnormality such as subsidence and fissure	50	
		Small abnormality such as subsidence and fissure	30	
		There is not abnormality	10	(b)
Type of foundation	Hydraulic Box Base		80	
	Pier Foundation		80	
	Spread Foundation		100	
	Does not know		100	
		Total		

(Bridge Pier [Bridge Pier Investigated :P]) (E)

Item	Abnormality	Clasification	Grade	Type of foundation
Scouring	river bed scouring around the foundation	There is not scouring		20
		footing or tob slab emergence	80	75
		inferior footing part emergence	100	90
			Total	(E) (100~15)

Evaluation of bridge abutment (G)

River bed stability	(F)
(A)+(B) max 100	
The highest between (F) y (D)	(G)

Evaluation of bridge abutment (G)

River bed stability and revetmd	(H)
(A)+(C) máximo100	(E)
Abnormality	
The biggest between (H) y (E)	(I)

Total evaluation of the bridge

The highest between (G) y (I)	(K)

[Total Evaluation]

Answer	Evaluation
It is needed to take countermeasures To respond to the elaboration of the disaster prevention manuel	
There is no need of new countermeasure	

Appendix A1.5 Record of the History of Damages (1/2)

Form - 5-1

No.	Type of disaster		Site	Kilometer post (of)	(to)		From Managua/ To	
Inspection Site Year	Respond / Not Respond			East longitude		North Latitude		
Plane (Damages, Measures)				Seccion (Damages, Measures)				
Pictures, Sketch of actual situation				Remarks				
				Date of disasters				
				Dimension	Wide, Long, Depth (m) m, m, m			
				Inciding factor	Precipitation: Continue mm/ hr·d Maximum m Earth quake: Magnitude			
				Damages	Human damages: deads Injuries: Material damages: Total cost of damages loss: Comments:			
				Traffic restriction record	1.Full restriction: hours 2. One way road restriction: hours. 3. Others:			
				Countermeasure	Year of construction: Type of works: Approximate Cost:			

Appendix A1.5 Record of the History of Damages (2/2)

(Scouring in the bridge foundation of the bridge)

Form - 5-2

No.	Type of disaste		Kilometer post	(to)			From Managua to	
Inspection site year	Respond / Not Respond		Longitude		Latitude			
Name of the Bridge		Year of the constructio	Length of the bridge	m.	Span	m.	Name of the river	

Plane of the bridge (Damages, Measures)

1. Around pier foundation.	3. Back embankment of the abut (left & right)
2. Protection of the sides around the about (left	4. Others.

Pictures, Sketch of the actual situation

Special Note (After the inspection of the year)

Dimensio	1 Destroyed Bridge (Superior structure(—)/Abut( )/Pier( ) 2 Inclination, bridge subsidence (Abut( )/Pier( )) 3 Subsidence of the back embankment (right side, left side) 4 Others: Comment
Inciting factor	Precipitation: Continuous mm/ hr-d Maximum mm/hr (Hurricane · Torrencial rain · Others)
Damages	Human damages: Dead Injured Material Damages Total losses: Comment:
Traffic Restriction	Complete Restriction: hours/Restriction of one track hours. Traffic Restriction in shoulder
Counter measures	Year of performance: Type of works: Works expenditures

Appendix A2

Type of Countermeasures (Chapter 7)

A2.1 Type of Countermeasures in the Case of Road Damage

A2.2 Type of Countermeasures against Slope Failure

A2.3 Type of Countermeasures against Bridge Foundation Scouring

Appendix A2.1 Type of Countermeasures in the Case of Road Damage

Classification	Type of Work	Functional Characteristics	Application	Illustration
(1) Earth Work	Removal	- To stabilize a slope by removing unstable potions - To remove unstable rocks before they falling down	- Cut slope - Generally applied to huge and medium-size rocks. **Rock-fall/collapsing** **Rock collapsing** **Slope damage** **Debris flow**	
	Recutting	- To stabilize a slope by cutting it to its optimum gradient.	- Cut slope(soil & rock) **Rock-fall/collapsing** **Rock collapsing** **Slope damage** **Debris flow**	
	Rock splitting	- To stabilize a slope by split it.	- Applied to huge rocks. **Rock-fall/collapsing** **Rock collapsing** **Debris flow**	
	Embankment	- To refill a cavity created by erosion, scouring, etc.	- Cut slope, fill slope. **Rock-fall/collapsing** **Slope damage** **Debris flow**	

Appendix A2.2 Type of Countermeasures against Slope Failures (1/5)

Classification	Type of Work	Functional Characteristics	Application	Illustration
(2) Vegetation	Hydroseeding	- To prevent the erosion, scouring and weathering of a slope by covering it with vegetation.	- Mainly applied to the weathered rock, soft rock and soil surface of a cut and fill slope. **Rock-fall/collapsing** **Rock collapsing** **Slope damage** **Debris flow**	
	Vegetation	- To prevent the erosion, scouring and weathering of slope by covering it with vegetation.	- Fill slope - Cut slope(soil) **Rock-fall/collapsing** **Slope damage** **Debris flow**	
(3) Surface Drainage	Crest ditch	- To prevent the erosion and scouring of a slope surface by collecting runoff water along the top of a cut slope	- Cut slope - Weathered rock, soil **Rock-fall/collapsing** **Rock collapsing** **Slope damage**	
	Berm ditch	- To prevent the erosion and scouring of a slope surface by collecting surface water in berm.	- Cut slope and fill slope. - Weathered rocks and soil **Rock-fall/collapsing** **Rock collapsing** **Slope damage**	

Appendix A2.2 Type of Countermeasures against Slope Failures (2/5)

Classification	Type of Work	Functional Characteristics	Application	Illustration
(3) Surface Drainage	Roadside drain	- To prevent runoff water from reaching a road's surface.	- Cut slope, fill slope. **Rock-fall/collapsing** **Rock collapsing** **Slope damage**	
(4) Structure	Stone pitching	- To protect a slope by covering it with stone pitching.	- Usually applied to a slope surface gentler than 1.5:1 **Rock-fall/collapsing** **Slope damage**	
	Shotcrete	- To protect a slope by covering it with sprayed concrete(or mortar)	- Cut slope(rock) - Not applicable to a slope surface with much seepage water. **Rock-fall/collapsing** **Rock collapsing** **Slope damage** **Debris flow**	
	Sprayed concrete crib	- To protect a slope by covering it with crib made with a gun.	- Applicable to a slope surface steeper than 1.0:1. - Applicable to an undulated surface. **Rock-fall/collapsing** **Rock collapsing** **Slope damage** **Debris flow**	

Appendix A2.2 Type of Countermeasures against Slope Failures (3/5)

Classification	Type of Work	Functional Characteristics	Application	Illustration
	Gabion Wall	- To protect a slope from landslides by resisting earth pressure.	- Mainly applied to the toe of a fill slope with seepage water. **Rock-fall/collapsing** **Rock collapsing** **Slope damage** **Debris flow**	
	Stone masonry wall	- To protect a slope from landslide by resisting earth pressure.	- Applicable to a stone masonry wall less than 5 m high. - Generally applied to a cut and fill slope. **Rock-fall/collapsing** **Rock collapsing** **Slope damage** **Debris flow**	
	Gravity-type retaining wall	- To protect a slope from landslides by resisting earth pressure.	- Applicable to a wall less than 3 m high. - Generally applied to a cut and fill slope. **Rock-fall/collapsing** **Rock collapsing** **Slope damage** **Debris flow**	
(4) Structure	T-shaped retaining wall	- To protect a slope from landslides by resisting earth pressure.	- Usually applied to a wall 3 to 10m high. - Generally applied to a cut or fill slope. **Rock-fall/collapsing** **Rock collapsing** **Slope damage** **Debris flow**	

Appendix A2.2 Type of Countermeasures against Slope Failures (4/5)

Classification	Type of Work	Functional Characteristics	Application	Illustration
(4) Structure	Pilling	- To prevent a slope from sliding by resisting earth pressure with piles.	- Applicable to a slope surface steeper than 1.0:1. - Applicable to an undulated surface. - **Slope damage** **Debris flow**	
(5) Protection	Prevention net	- To prevent falling rock from reaching a road by providing a catch wire net.	- Applied where there is no roadside space. - Unsuitable for a slope with rock that easily weathers. **Rock-fall/collapsing** **Rock collapsing**	
	Prevention fence	- To prevent falling rock from reaching a road by providing a catch fence.	- Applied where there is sufficient roadside space to contain fallen rock. **Rock-fall/collapsing** **Rock collapsing**	
	Barrier with concrete wall	- To prevent falling rock from reaching a road by providing a concrete wall.	- Applied where there is sufficient roadside space to contain fallen rock. **Rock-fall/collapsing** **Rock collapsing**	

Appendix A2.2 Type of Countermeasures against Slope Failures (5/5)

Classification	Type of Work	Functional Characteristics	Application	Illustration
(5) Protection	Rock bolt	- To prevent unstable rocks from falling down by anchoring them to bedrock with rock bolt.	- Applicable to huge rocks. **Rock-fall/collapsing** **Rock collapsing**	
	Rock shed	- To prevent unstable rocks from falling down by rock shed and debris flow.	- Cut slope - Debris flow **Rock-fall/collapsing** **Rock collapsing** **Debris flow**	
	Concrete dam	- To prevent a slope from debris flow by concrete dam.	- Debris flow **Debris flow**	

Appendix A2.3 Type of Countermeasures against Bridge Foundation Scouring

Classification	Type of Work	Functional Characteristics	Application	Illustration
(1) Abutment and protection	Concrete revetments	- To protect an abutment fill slope from scouring.	- Usually applied to a slope gentler than 1:1 **Bridge**	
	Stone riprap revetments	- To protect an abutment fill slope from scouring.	- Usually applied to a slope gentler than 1:1 **Bridge**	
	Gabion mat protection	- To prevent falling rock from reaching a road by providing a catch fence.	- Applicable to a long and short bridge. **Bridge**	
	Dumped rock/ Gabion mat protection	- To prevent an abutment from scouring by dumped rock or placing gabion mat.	- Applicable to a long and short bridge. -Generally applied to emergency work. **Bridge**	