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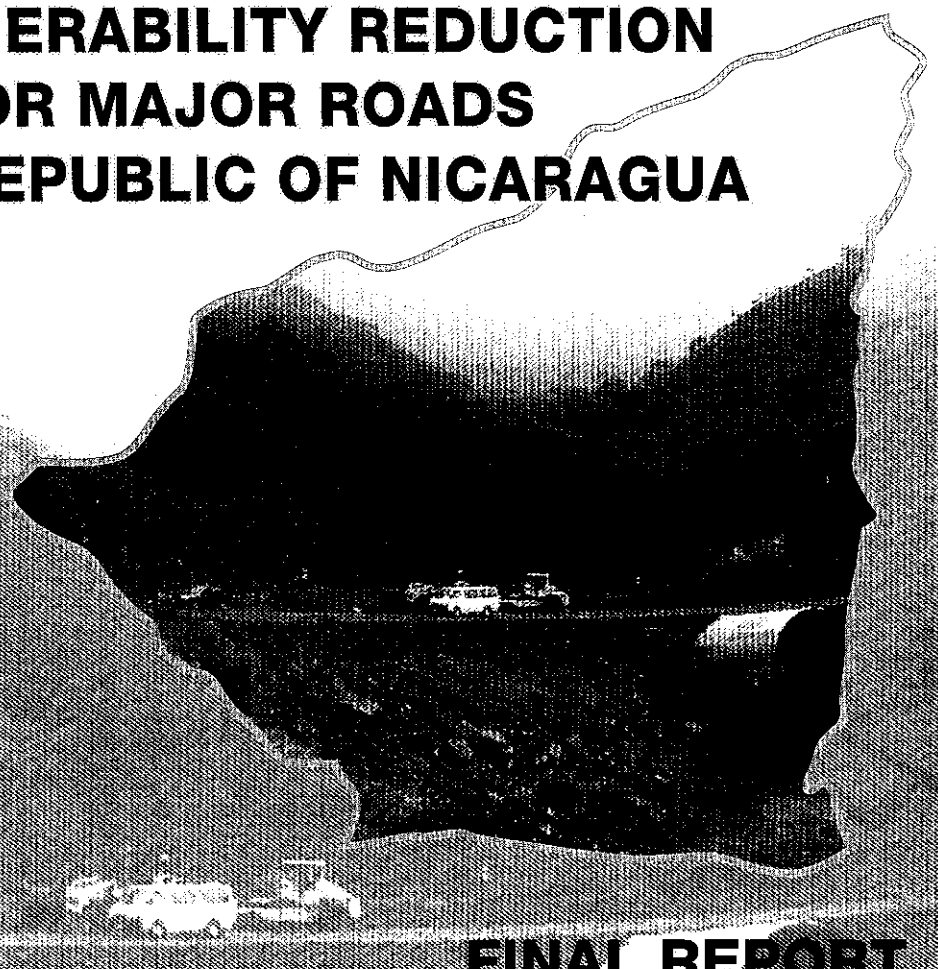
JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)

MINISTRY OF TRANSPORT AND
INFRASTRUCTURE
REPUBLIC OF NICARAGUA

THE STUDY ON VULNERABILITY REDUCTION FOR MAJOR ROADS IN THE REPUBLIC OF NICARAGUA



FINAL REPORT

Volume 5 of 5 (4/4)

MAINTENANCE MANUAL

January 2003

ORICONSUL Oriental Consultants Company Limited

Japan Engineering Consultants Company Limited

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List of Abbreviations
(In alphabetical order)

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
AHP	:	Analytic Hierarchy Process
ASTM		American Society for Testing and Materials
B/C	:	Benefit to Cost ratio
BH		Boring Hole
BHN	:	Basic Human Needs
BIT		Central American Development Bank
DID		Densely Inhabitant District
EIA	:	Environmental Impact Assessment
GDP	:	Gross Domestic Product
GRN	:	The Government of Republic of Nicaragua
ID		Identification
IDF	:	Rainfall Intensity Duration Frequency
IEE	:	Initial Environmental Examination
INETER	:	Institution of National Territorial Study
IRR	:	Internal Rate of Return
JICA		Japan International Cooperation Agency
MARENA	:	The Ministry of Natural Resources and Environment
MTI	:	The Ministry of Transport and Infrastructure
OD	:	Origin and Destination
PRSP	:	Poverty Reduction Strategy paper
QV	:	Volume capacity
ROW	:	Right of Way
STRADA		System for Traffic Demand Analysis
VAT		Value Added Tax
VOC	:	Vehicle Operation Cost
WB		World Bank
pcu	:	Passenger Car Unit

The following foreign exchange rate is applied in the study :

1 US dollar = 14.40 Cordovas = 125.00 Japanese Yen (October 2002), or

1 Cordovas = 8.68 Japanese Yen

CHAPTER 1 INTRODUCTION

1.1 General

This manual has been produced for the Ministry of Transport and Infrastructure (MTI), who will manage the road disaster prevention of major and rural roads in Nicaragua, by the Japan International Cooperation Agency (JICA). The Direction of Road Maintenance, General Direction of Road, in MTI (DRM) has managed and been responsibility for the maintenance works of all roads controlled by MTI. Therefore, in order to achieve the reliable maintenance works, all roads under DRM should be maintained in accordance with this manual.

Maintenance works for road disaster prevention are one of the fundamental factors in increasing the socio-economic performance of a nation. Therefore, activation of the populace and safety control of the road users are dependent on the results of the premeditated maintenance. Efforts that every day does not slacken are important for securing the stable transportation of products. Due to his duty, DRM, Engineers, inspectors, technicians and maintenance staffs should execute road maintenance work based on same policy and methods.

This series of road disaster prevention manual are composed of four parts as follow.

Part I : Inspection Manual
Part II : Planning Manual
Part III : Design/ Execution Works Manual
Part IV : Maintenance Manual

This is Part IV "Maintenance Manual".

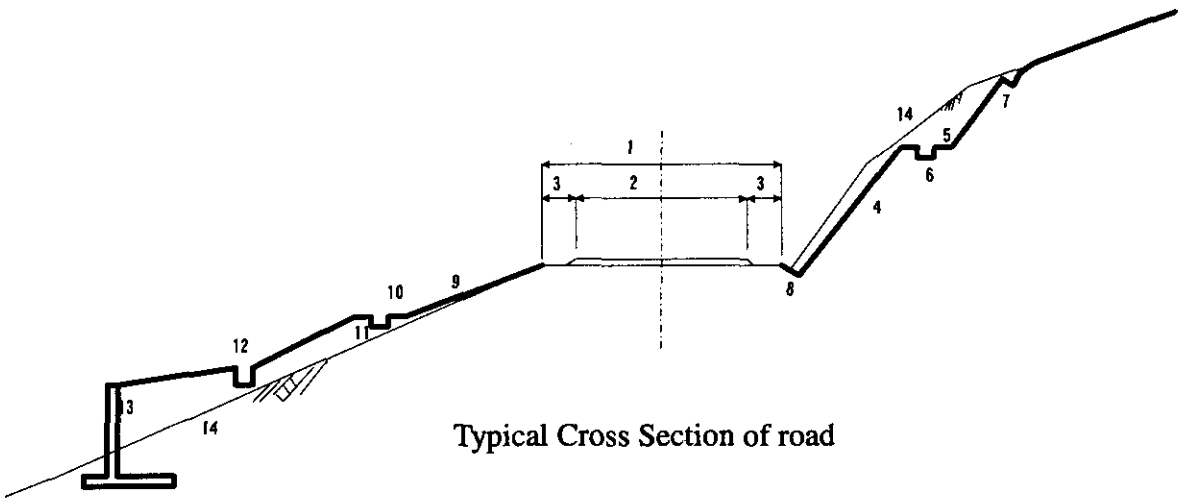
This Manual has taken account of natural conditions, road geometries and environmental condition. Engineers, Inspectors, Technicians and maintenance staffs should be kept on doing maintenance.

1.2 Glossary of Terms

This Chapter contains a glossary of terms that are used in this manual.

1.2.1 Cross Section

The typical road cross section is as the following figure. Almost cut slopes, embankments and ditches, etc. are not enough safeguard against failure. Therefore, this manual contains proposals shown in following figure as bold lines.



Typical Cross Section of road

Key;

1. Roadway
2. Carriageway
3. Shoulder
4. Cut Slope
5. Berm
6. Berm Ditch
7. Crest Ditch
8. Roadside Drain
9. Embankment Slope
10. Berm
11. Berm Ditch
12. Berm Ditch
13. Structure
14. Existing Slope

1.2.2 Glossary of Terms

The main "Glossary Terms" are as follows.

AHP This is one of evaluation method for selecting the high priority disaster spots. AHP is an abbreviation of the Analytic Hierarchy Process.

Catchment Area The area from which water runs off by gravity to a collecting point.

Culvert A duct, usually rectangular or circular, for carrying surface water under the road.

Gabion The steel mesh cage filled with cobble stone or crushed stone. This is mainly used for revetment, foot protection and rockfalling protection.

Disaster Critical Spots Disaster critical spots should be defined in consideration of the following items to the disaster potential spots:
- Disaster scale/ records at area of spots,
- Necessary spots for emergency,
- Critical spots for third persons,
- Topographic data by preliminary topographic survey, and
- Sketch of site condition.

Disaster Potential Spots Disaster potential spots are defined when there are:
- boulders on slope surfaces,
- many cracks on rock surfaces,
- small rock fallings, and
- historical disaster records regarding rock-fall, rock collapsing, slope slide, scouring of bridge foundation.

Disaster Prevention Spot Where countermeasures against disaster are proposed, Which addressed the following:
- Stability level of damage spots,
- Traffic volume of objective road,
- Environmental evaluation,
- Natural condition,
- Benefits/ Rough cost estimate,
- Restoration level of damaged spot, and
- Development situation.

Emergency Countermeasure
- It means that a serious and dangerous spot must be improved immediately.
- The lifetime of countermeasures should be until the next rainy season or less than a half year.
- It is necessary to decide upon the implementation of temporary countermeasures or permanent ones during the lifetime of the emergency countermeasures.

Emergency Inspection

<Time of Year>: The Emergency Inspection must be carried out just before any forecast hurricane or heavy rain.

<Spots> : Slope spots previously damaged, seepage water spots on slope and severe scouring spots at bridge foundations, must be carefully inspected and be written on the survey sheets by Inspectors.

<Frequency> : Just before hurricane or heavy rain.

Inspector

Inspector means a member of Inspection Team. Inspection team is composed of a Engineer and two assistants.

Periodic Inspection

<Time of Year>: The Periodic Inspection must be carried out before the rainy season (usually around September) or after earthquake occurred.

<Spots> : At least, whole slopes of disaster potential spots, and around the bridges at disaster potential spots must be inspected and be written on the survey sheets by Inspectors.

<Frequency> : Once every year

Permanent Countermeasure

- The lifetime of countermeasures should be least twenty (20) years during the maintenance work.
- An adequate budget for permanent countermeasures should be safeguarded at all times.

Routine Inspection

<Time of Year>: The Periodic Inspection must be carried out as general inspection throughout the year.

<Spots> : Whole slopes and bridges on the objective major road is inspected and be written on the survey, if some abnormality occur.

<Frequency> : Once for a week

Screening

The objective of screening is as follows:
- Objective inspection of vulnerable spots,
- Early detection of vulnerable spots, and
- Characteristic grasp of vulnerable spots.

Temporary Countermeasure

The lifetime of countermeasures should be at least ten (10) years during the maintenance work.

1.3 Relating Law

Each regulation for construction work of disaster critical spots is described in this Section. There are two regulations for construction work and for its transportation of materials and machines.

1.3.1 Law 337

National Committee has managed the National system for the Prevention, Mitigation and Disasters in Nicaragua. The following contents have extracted from the Creator Law of National system.

Chapter 1: General Dispositions

Art. 3 Basics Definitions

Numeral 7 Disasters:

In all situations that cause intense alterations for the social, physical, ecological and cultural society components, taking to imminent danger the human life and the personal and national goodness, surpass the local answer capacity to give efficiently attention to the consequences; it could be from a natural origin or caused by the man.

Numeral 8: Natural Disasters

This damages are caused by any natural phenomenon, this could be a hurricane, a twister, storm, high tide, inundation, tsunami, earthquake or volcanic eruptions, land slide, forest fire, agriculture blight, dried and others that as result will affect the population, the infrastructure and some productive sectors from the different economical activities, in a high scale that overcome the capacity for local answers and require the regional help; at the request of one or more of the affected parts to complete the able resources efforts on it, so that the damages and the loss could be mitigate.

Numeral 12. Disasters Prevention

It is call to the group of activities and measures from a technical and legal character that has to be done in a Socio- economical development Planning process, so that the loss of humans life and damages on the economy could be avoid as a consequence of the natural disasters.

Art. 7 National System Functions

Part 1.
Design, ratify and execute the disasters prevention plan.

Part 10

To establish the agreement for Scientific-Technical cooperation for countries with more experience on it.

Chapter II

From the National Commitment of the National System for Prevention, Mitigation and disasters attention

Art. 9. National Commitment of the National System.

The national commitment of the National system, from now on is call National Commitment; it is the ruling instance and the one who can establish the political, planning, direction and the system coordination all over their activities.

Art. 10. National Commitment integration.

The national commitment joint to the State ministries or their represent, is going to be presided by the president of the republic or the vice president. This National Commitment has a permanent character.
The sessions works of the national commitment have to be on the running time at least two times in the year and they will regulated themselves with the Rules established on the present law. This commitment is going to be conformed as follows:

1. President of the Republic or a representative
2. Secretary of Defend , companied with the Chief of the national army
3. Secretary of Interior , companied with the chief of the national police.
4. Secretary of state
5. Secretary of Treasure and public credit.
6. Secretary of Foment, Industry and business.
7. Secretary of health
8. Secretary of Transport and Infrastructure
9. Secretary of environment and Natural resources
10. Secretary of the Family

11. Secretary of Education, Culture and sport.
12. Director of Territorial Study institute.

Art. 11 Commitment functions

For the present law and their ruling, it is function of the National commitment the following aspects:

1. Definitions of the national system politics
2. Approve the national plan for the national system
3. Propose to the president of the republic the declaration of the disaster conditions.
4. Approve the annual purpose for the national disaster fond.

Propose the adoption of required measures and instruments to make useful the objectives of the national system, such as territorial order and education, and more.

5. Creation of the procedures on instruments for the control and distribution of the international help.
6. Approve the norms and regulation propose of the territorial order for the disasters prevention.
7. Convoke, such as adviser, to the governmental and non governmental organisms.
8. Approve the items and contents of the study that has to be include on the education programs of the Department of Education, culture and Sports, such as the others institutions of the technical education and superior, about prevention, mitigation, and disasters attention.

In the Department of Transport and Infrastructure exist a technical joint unity for disasters that are direct dependant from the Superior direction of the MTI and in case that disasters occur is attended by the General Director of Constructions Norms and urban Development.

1.3.2 NIC 2000

Sub division 100
Section 105 Work reach

1. General

105.07 Dispositions about the Traffic Control

The contractor can not close to the traffic for any reason publics routs or stretch or bridge without a previous writing approve by the engineer. Neither can start with the constructions works that for any reason left the public road on non adequate conditions for the traffic flow, with out a previous temporary construction approved by the engineer based on the commodity and security aspects.

Other wise it is arrange on a different way on the draws, preventive signs should be installed far away from the project limits, at least 150 meters from each side. And at least 150 m form another project site where the constructions works interfere with the public traffic that use the route.

During the night should be working flashing beacon, lanterns. Electrical and reflective instruments and any other approved light sign in the places where it is necessary.

Where it is necessary and the places where the engineer said, should be use a standard bearer , or pilots cars or routs savers with the purpose to guide and arrange the traffic and pedestrian circulation. The workers should be wearing uniforms or specials jackets and pennant or manual signs so that they could be easily seen by the drivers during the day and the night.

When the works are done on adjacent areas of lanes to open traffic areas, the borders of the lanes or of the pavement should be defined trough portable definers placed on the whole length and parallel to the border.

105.06 Traffic Maintenance

1. Construction of the Road by band.

Specially in case of paving or re-paving, the contractor could, if the engineer approve, proceed to work with band, leaving free a space with a enough wide for the secure and comfortable traffic pass and controlling trough the standard bearer or pilots car; on both opposites routs of traffic circulation.

Ruling for the load control and dimensions of the load carrying vehicles that transit on the Road network of Nicaragua (MTI) March 2002

Art. 9 It is establish that the carried load should respect the following aspects.

1. No load could be more than 1.0 m from the back side of a vehicle.
2. Any loaded or unloaded vehicle could exceed the follow dimensions:

Wide: 2.60 m.
Height: 4.15 m. (starting form the running surface)
Length: a) 2 axes : 11.0m.
b) 3 axes: 12.0 m.
c) half tow truck : 17.35m.
d) others combinations: 18.3 m.

Art. 19

When for any reason of general interest, had to be occasionally transported, heavy machines or other invisibles objects, on load carry vehicles allowed to use the country road network which load and dimensions exceed the indicated on appendix that are stipulated on this ruling, a special permission is granted by the Road General Direction at the request of the owner of the special load at least previously 3 days before the carry of the load, which has limited urgency just for the particular trip.

Art. 20

In each special permission it is going to be specify the type of load, the rout that is going to follow and the appropriate time, the circulation speed on the roads and specially on bridges, accompaniment of radio squad and others protections measures of the road network and safety of the others users.

Art. 42

Motorized vehicles or their combinations should have pneumatic tires or dispositives with enough elastic surface. It is prohibit to use metallic objects that are prominent on the running surface of the tire. The tires pressure on none case can exceed the load of 8.4 kg/cm^2. It is prohibit to circulate with chains or metallic bands.

1.3.3 Law for Vehicles and Traffic

Art. 61

It is totally prohibit to carry objects that are prominent from the external sides of vehicles and every time that they are prominent form the posterior side of the vehicle, they should be provide with a red scarf, if it is during the day; or a red light if it is during the night.

Note: Law approved on may 10, 1938

CHAPTER 2 MAINTENANCE CRITERIA

2.1 General

When maintenance is done, it is necessary to consider basic backgrounds of the characteristic of the road facility in the slope and the bridge, etc. and the socially impact etc. of each roads. The situation of the road facility in the slope and the bridge, etc. is understood by inspection, and the maintenance work is executed based on obtained information. It is necessary to try to always maintain the road facility in the slope and the bridge, etc. excellently, and to prevent the disaster beforehand.

The road facility in the slope and the bridge, etc. becomes superannuated and vulnerable as the age is passed. Moreover, The external force not considered when constructing loaded, and it is likely to collapse when it is extreme.

The road facilities in the slope and the bridge, etc. bounds to a road traffic space, the transformation of these facilities effect directly to the road traffic, it is not only interception of traffic when the collapse is generated but also threatens the life and the property, and will require large cost for the restoration.

2.2 Type of Maintenance Inspection

The maintenance inspection has the type shown in the following according to the purpose.

-Routine inspection
-Periodic inspection
-Emergency inspection

1) Routine Inspection

The purpose of routine inspection is the early detection of the transformation. This inspection is visually done the range that can be checked visually from patrol car.

The routine inspection is usually assumed to be one time per one week, but it is preferable to increase and decrease the inspection frequency by the situation of slope and bridge, traffic volume, social environments etc. The main purpose of the routine inspection is shown in the following;

- Inspection of smooth flow of traffic
- Inspection of existence of collapsed rock and debris on road.

- Inspection of situation of road structures, slope, drainage facilities. If the damages and abnormalities are found, inspect carefully, and record for trace and reporting.
- In case of imminent situation, it needs urgent countermeasures.

The inspection and record items of the routine inspection are shown in Table 2.2.1.

Table 2.2.1 The Inspection and Record Items of the Routine Inspection

Position	Inspection and Record Items
On road	-falling and diffusion of rock and debris
Shoulder	-presence of crack -new progress of crack
Drainage Facility	-storage of falling rock and debris
Slope	-presence of rock falling, rock collapsing, and land slide -conceive, crack -weathering, gully erosion -spring water, volume of underground water -transformation, crack and collapsing of cribwork, retaining wall, and shotcrete -damage and corrosion of 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 of river channel -storage of deposit

2) Periodic Inspection

The periodic inspection is to approach the slope and the bridge etc. by walking, and to inspect the detail as much as possible.

The periodic inspection is usually assumed to be one time per one year, but it is preferable to increase and decrease the inspection frequency by the situation of slope and bridge, traffic volume, social environments etc. The main purpose of the periodic inspection is shown in the following;

- Inspection of stability of slope, transformation of road facilities, Level of damage and deterioration
- The situation of the springing water from the slope and the drainage system is confirmed by inspecting in the rainy season.
- It should be recorded as a database.
- It is necessary to inspect by a special engineer and the technician.

3) Emergency Inspection

A emergency inspection is executed after the heavy rainfall and the earthquake. It is executed to supplement a routine and periodic inspection if necessary.

As for a emergency inspection, the following two cases are considered. The first case is when the disaster occurred; the second case is to appear symptom of transformation and progress to disaster. The purpose of inspection is to get information for planning of measurement at the disaster. The main purpose of the periodic inspection is shown in the following;

- More than one expert should do the detailed inspection emphatically and multilaterally.
- The sketch, which indicated location, direction, and width of crack, a present condition photograph, and a crack distribution chart, are created. Moreover, measurement investigation is performed if needed and a topographical map, a sectional view, etc. are created.
- Inspection should be done rapidly after a rainstorm, a heavy rain, an earthquake, etc. because transformation of slope occur easily. The appropriate measures should be executed if necessary.
- When the symptom of the transformation appears, a detailed inspection of partial or overall should be executed. Measurement equipment, such as a surface-of-the-earth extensometer and inclinometer of ground for investigating are installed for movement of soil sprit and crack progress.
- If the movement is progressing, the movement should be observed continually. 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, landslide, etc. occur, in order to grasp the present condition, it bores in order to investigate the section of the movement direction, and slide surface groundwater, soil condition etc. are investigated.

The flow of the maintenance management is shown in Figure 2.2.1.

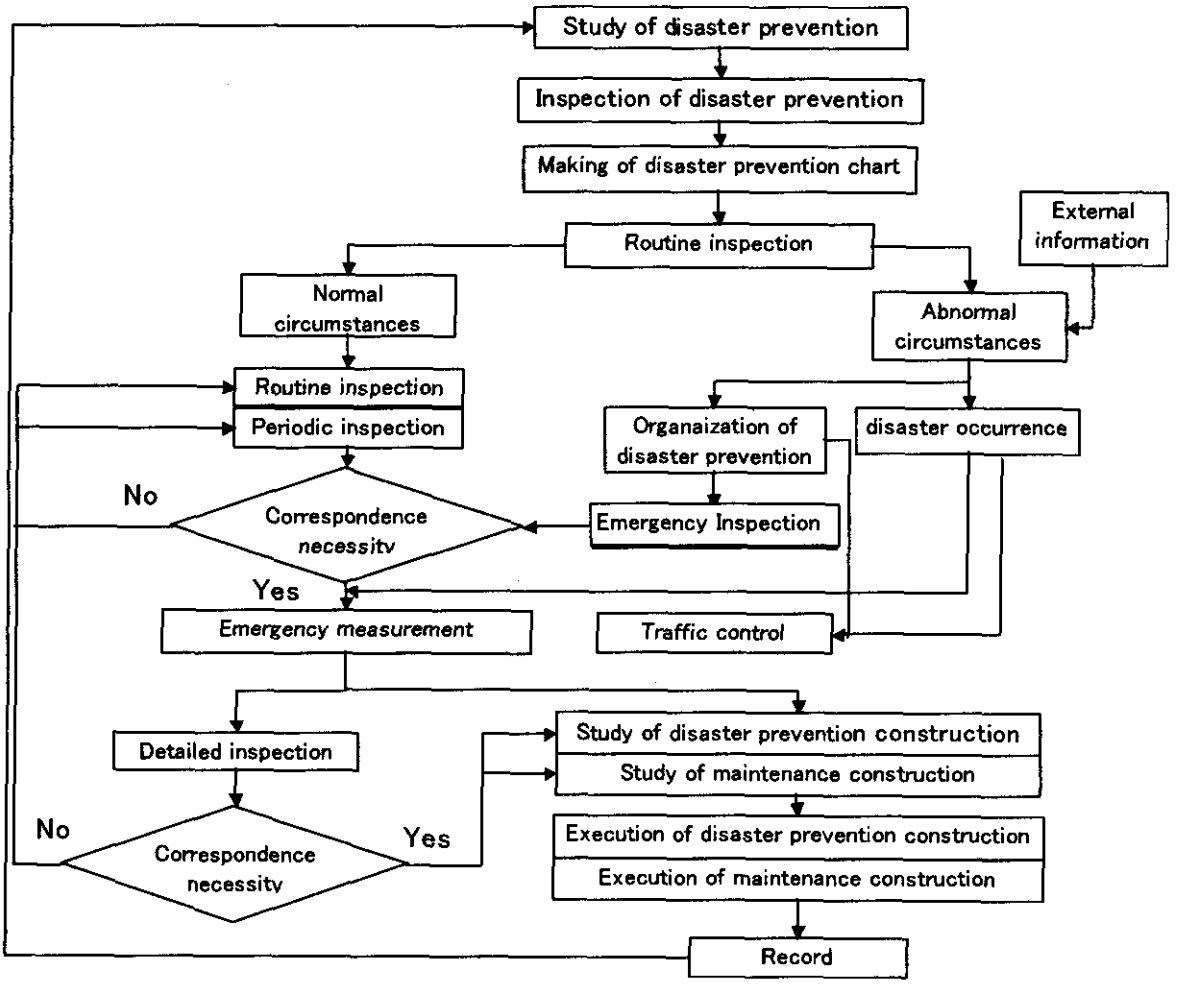


Figure 2.2.1 Flow Chart of Maintenance Management

2.3 Methods of Repair/ Rehabilitation

2.3.1 Attention Items

Attention items of methods of repair and rehabilitation are shown in the following;

- The secondary disaster prevention gives priority after confirmation of dread of secondary disaster and work safety.
- Confirmation of detour.
- Confirmation of appropriate scale for repair and rehabilitation.
- The repair and rehabilitation methods are selected in consideration of the situation of the material arrangement.
- In the guess of the transformation and the collapse cause, various inventory are used.

2.3.2 Type of Method of Repair and Rehabilitation

1) Crack and Damage on Slope

The selection of the method of repair and rehabilitation is shown in Figure 2.3.1.

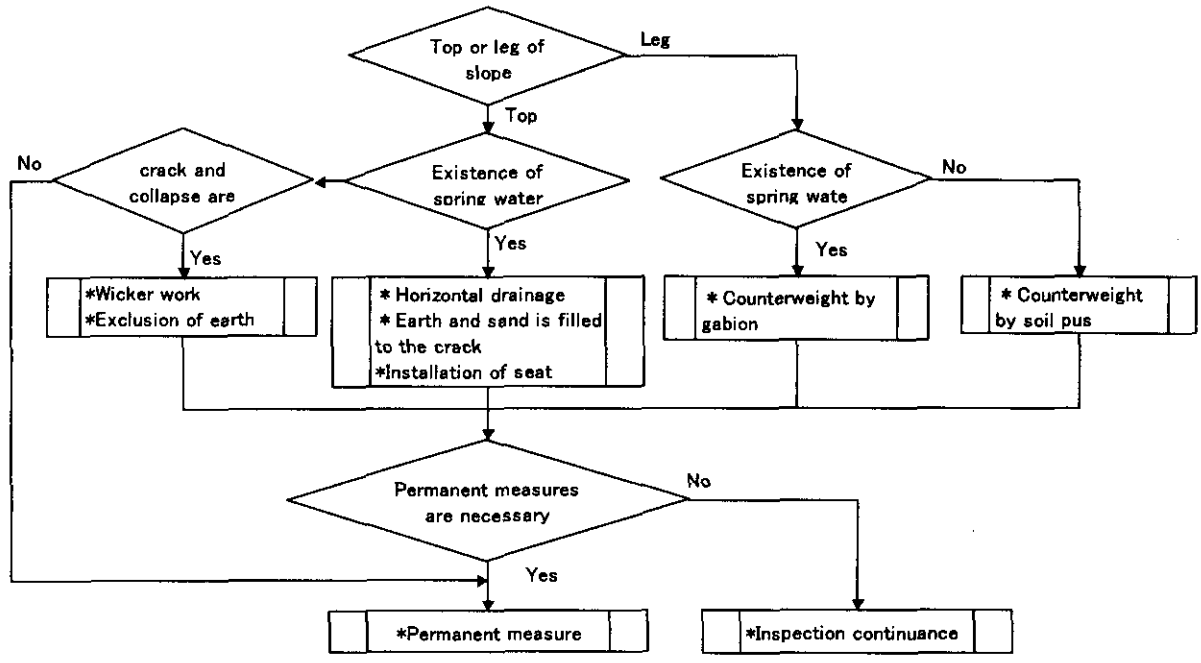


Figure 2.3.1 Method of Repair/ Rehabilitation of Crack and Damage on Slope

2) Boulder Stone and Unfixed Stone on Slope

The selection of the method of repair and rehabilitation is shown in Figure 2.3.2.

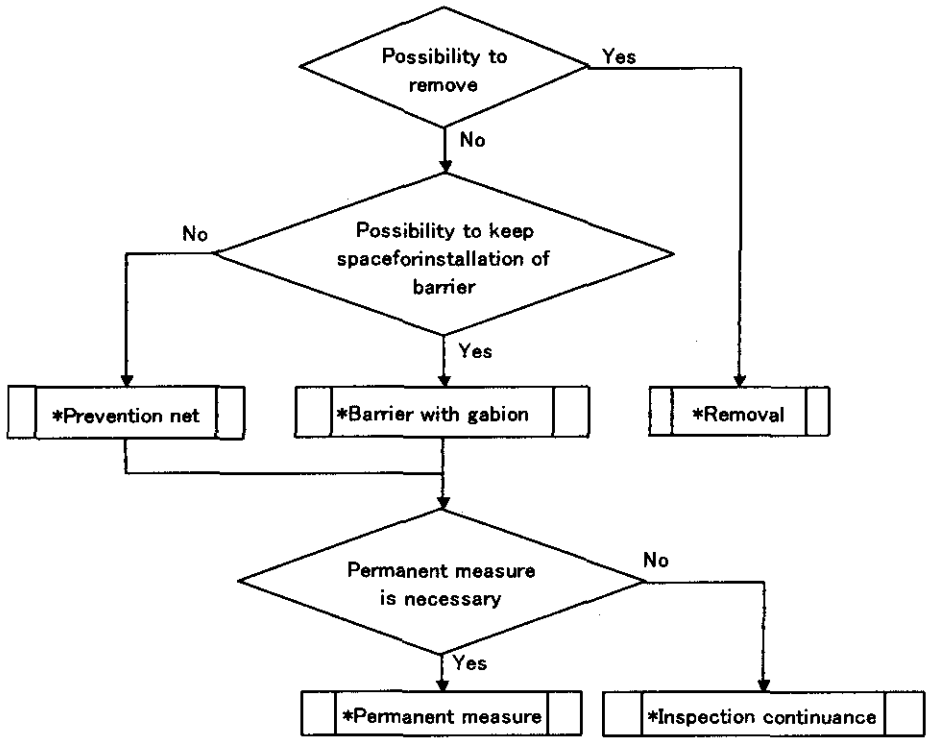


Figure 2.3.2 Method of Repair/ Rehabilitation of Boulder Stone and Unfixed Stone on Slope

3) Defect of Drain and Weathering of Shotcrete

The selection of the method of repair and rehabilitation is shown in Figure 2.3.3.

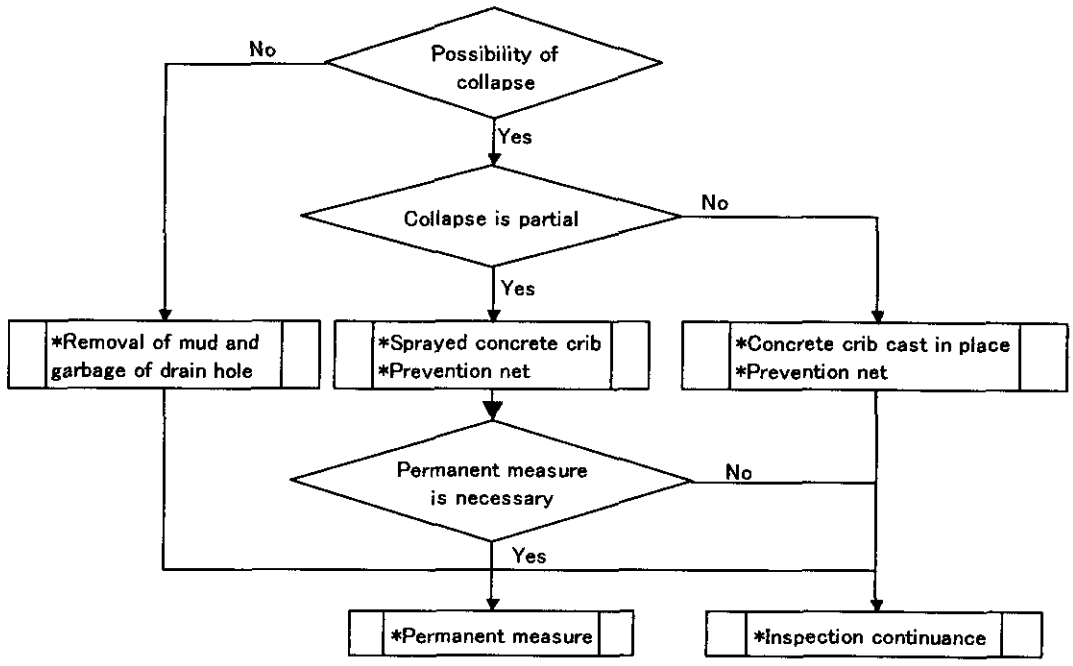


Figure 2.3.3 Method of Repair/ Rehabilitation of Defect of Drain and Weathering of Shotcrete

4) Slope Damage by Road Surface Water Inflow Concentrated to Embankment

The selection of the method of repair and rehabilitation is shown in Figure 2.3.4.

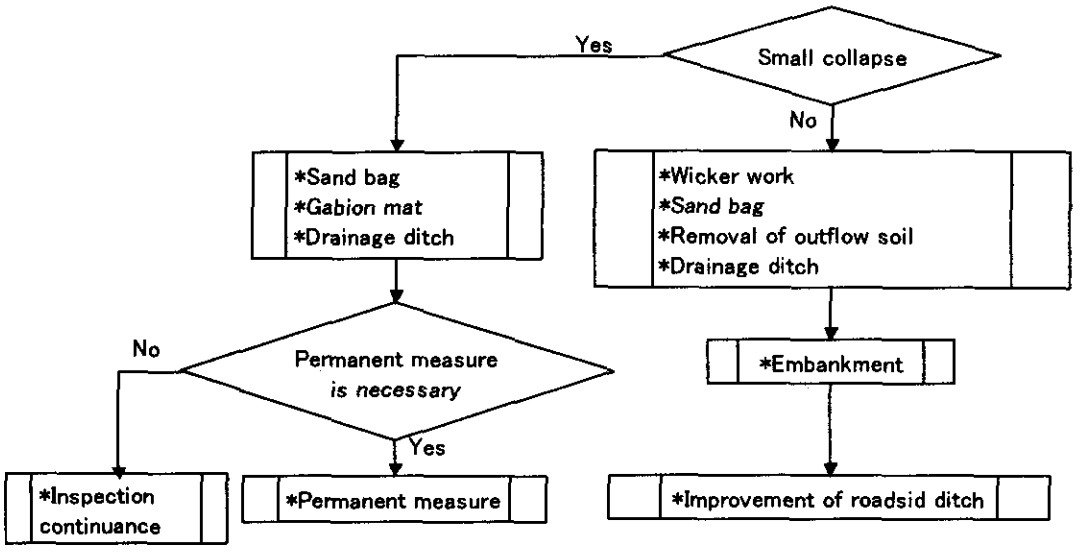


Figure 2.3.4 Method of Repair/ Rehabilitation of Slope Damage by Road Surface Water Inflow Concentrated to Embankment

5) Slopeslide

The selection of the method of repair and rehabilitation is shown in Figure 2.3.5.

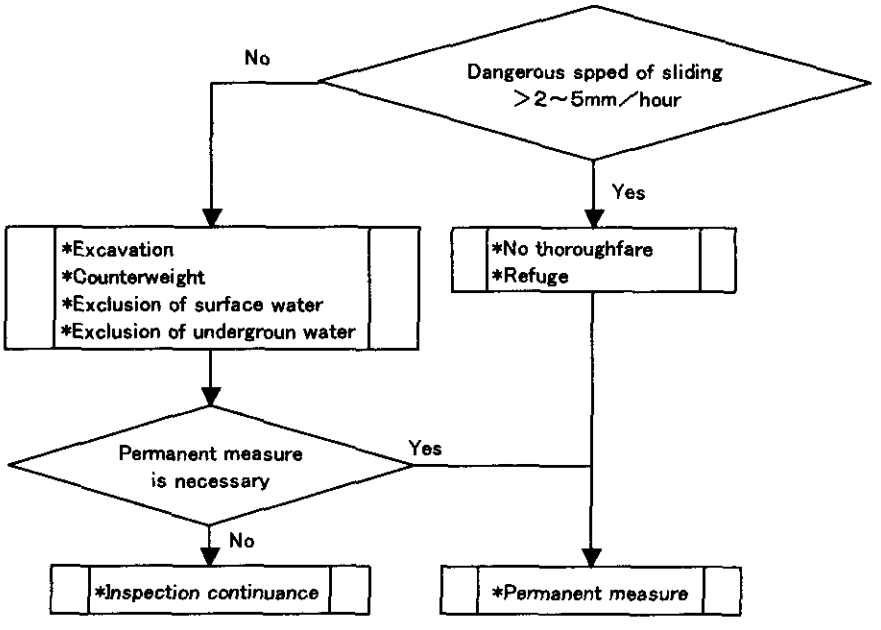


Figure 2.3.5 Method of Repair/ Rehabilitation of Slopeslide

CHAPTER 3 MAINTENANCE METHOD

3.1 General

When maintenance is executed, it is necessary to do by a systematic technique.

Firstly, compose the organization unit for functional maintenance the first in MTI. Secondary, execute effective patrol and the check. Finality, secure materials and machine parts for a repair in the emergency, which is at least necessary.

Here, the first and item second are referred.

3.2 Method of Repair/Rehabilitation/Improvement/Strengthening

Each local sub branch station of MTI (Regional Office) investigates the check work about the object road in the charge area.

When usually checking in the disaster prevention check, the maintenance straightening of the road facility is usually checked simultaneously. Therefore, frequency is about once a week. See Section 2.6 in the Inspection Manual.

The range of the object cannot check the same part once a week because objective is wide.
To check efficiently, the date and the course, etc. is set conveniently.

The periodic inspection does an emphatic investigation including the details part in which it aimed at the maintenance of the road disaster prevention facilities.

A temporary inspection is executed after the heavy rainfall and the earthquake. It is executed to supplement a routine and periodic inspection if necessary.

The investigator understands information by the site investigation, and sets up the barricade in a dangerous part in the emergency.

In addition, the investigator informs the driver of danger by setting up the traffic-control sign.