ROAD DISASTER PREVENTION MANAGEMENT MANUAL

GUIDE III

MANAGEMENT FOR IMMINENT DANGER

ABC
JICA

CONTENTS

GUIDE III MANAGEMENT FOR IMMINENT DANGER

1 EARLY WARNING FOR WIDE AREA BY PRECIPITATION MONITORING
- **1.1 SETTING OF SIMPLE RAIN GAUGES AT THE MICRO-EMPRESAS STATIONS**
- **1.2 ALERT LEVEL**
- **1.3 CORRESPONDENCE FOR EMERGENCY (PRE-DISASTER)**

2 EARLY WARNING AT HIGH RISK SPOT
- **2.1 SELECTION OF HIGH RISK SPOT**
- **2.2 INSTRUMENTATION**
- **2.3 ALERT LEVEL**
- **2.4 CORRESPONDENCE FOR EMERGENCY (PRE-DISASTER)**

APPENDIX III-1 EARLY WARNING

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING SYSTEMS

APPENDIX III-3 RAIN GAUGE MONITORING RESULT

CONTENTS

OUTLINE

This is a guide that indicates actions and replies should be taken in emergency cases before disaster and mid disaster. The emergency responses shall be covered just on High Hazard Control Sections and High Risk Control Sections which assigned by ABC Regional Offices in Guide I. As the practical method in Bolivia, the simple rain gauge as warning device made of cylindrical shape container with scale shall be installed at all the Micro-empresas stations, and shall be monitored by the Micro-empresas. Before disaster, when the monitoring shows that the road is in critical moment, emergency level is activated. Emergency level is classified into three levels based on the monitoring result. The activation of emergency is based on the emergency levels. When an emergency is found in highest hazard levels, the traffic shall be closed. The guide introduced emergencies response in disaster and after disaster.

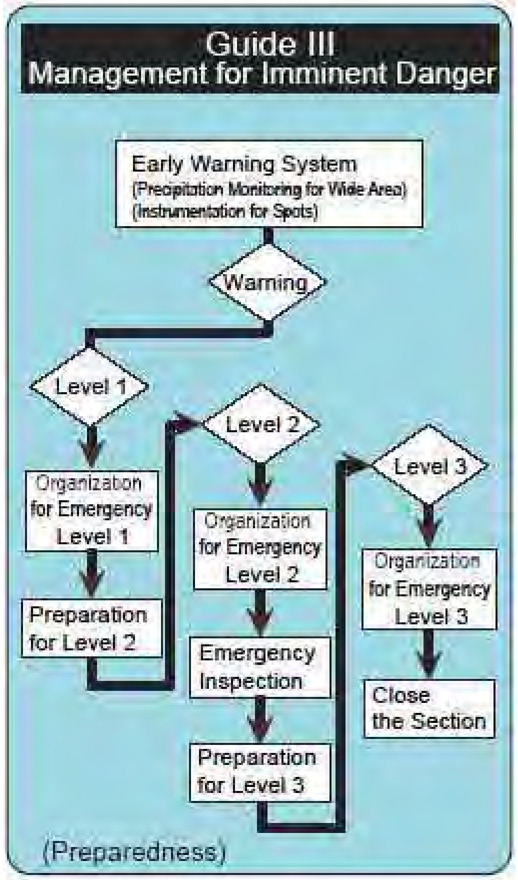


Figure 0.1 Contents of Guide III

1 EARLY WARNING FOR WIDE AREA BY PRECIPITATION MONITORING

For the national highway network in the nation, precipitation monitoring and instrumentations for slope disasters have not been prepared properly at the moment. The instrumentation and monitoring of the rain gauge and other instrumentations are recommended for early warning in Bolivia. This guide introduced simple and easy instrumentation for the first introduction of the early warning systems.

This precipitation monitoring scheme could supply very useful information not only for the road disaster management but also data for meteorological study and agricultural industry.

1.1 SETTING OF SIMPLE RAIN GAUGES AT THE MICRO-EMPRESAS STATIONS

(1) Setting of Simple Rain Gauges

To prevent large funds for introduction of many rain gauges for the national highway network in Bolivia, it is recommendable as a primary stage of the road disaster prevention program to set a simplified rain gauge at each Micro-empresas' station. The Micro-empresas shall make simple rain gauges made of cylindrical containers under the Supervisors' instruction, and set at the Micro-empresas' own premises where there is no impediment such as tree to precipitation monitoring.

(2) Precipitation Monitoring and record

Integrated precipitation (depth of water in a rain gauge) shall be monitored and recorded on the monitoring sheet at every hour on the hour when rainfall started. The rainfall restarts within three hours after rainfall halt, the monitoring shall be resumed from last integrated precipitation. If the rainfall has been stopped for over three hours, the rainwater in the rain gauge shall be discarded.

The monitoring is recommended continuing even in mid night. However, if it is difficult to continue the monitoring, only start time of rainfall and integrated precipitation of the time of monitoring resumed shall be recorded and mark triangles in the times before monitoring.

1 EARLY WARNING FOR WIDE AREA BY PRECIPITATION MONITORING

EXAMPLE OF RAIN GAUGE

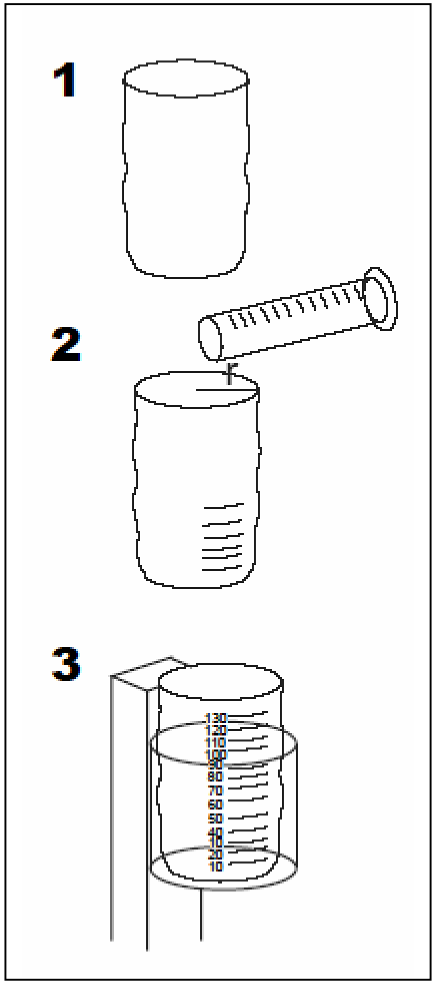


Figure 1.1 Making of Simple Rain Gauge

A simple rain gauge introduced here can not be used for official precipitation monitoring, but it is useful to know precipitation and to use for imminent danger.

Making of Simple Rain Gauge (figure left)

1. cut the bottle about 10 cm from its top.

2. measure inner radius of the cutting section. Put a grade scale on the bottle based on a following formula which show the relation between the radius and the volume.

$$v = h \times 2\pi\ r^2$$

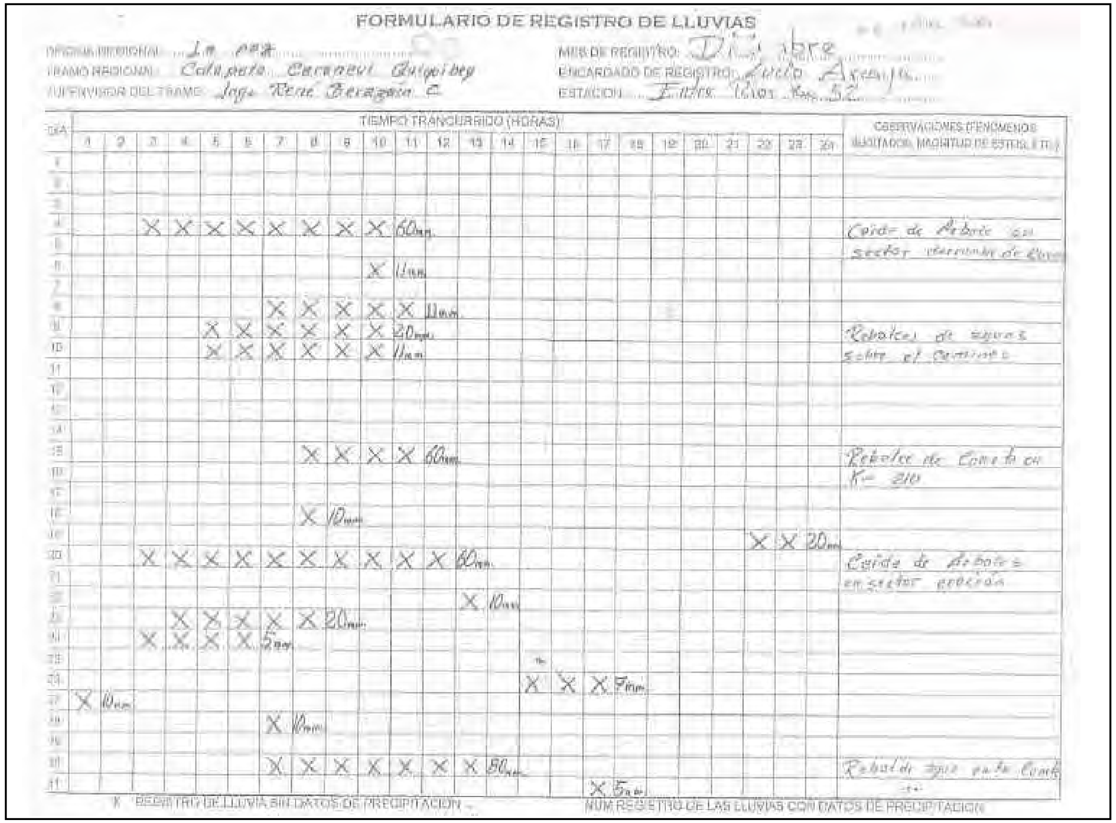
v : volume at the height h on the bottle (mm^2)
h : height of measuring scale (mm)
r : radius of cut section (mm)

3. Fix an empty can of which diameter is larger than the bottle on a stake, and put the simple range in the empty can.

1 EARLY WARNING FOR WIDE AREA BY PRECIPITATION MONITORING

RECORD OF RAIN GAUGE

Table 1.1 Example of Precipitation Monitoring Record
(Result of Rain Gauge Monitoring in the trial in 2006)



FORMULARIO DE REGISTRO DE LLUVIAS

OFICINA REGIONAL: La paz
TRAMO REGIONAL: Cotapata Caranavi Quiquibey
SUPERVISOR DEL TRAMO: Ing. René Berazain C.
MES DE REGISTRO: Diciembre
ENCARGADO DE REGISTRO: Lucio Araujo
ESTACION: Entre Ríos Km. 52

DIA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	OBSERVACIONES (FENOMENOS SUSCITADOS, MAGNITUD DE ESTOS, ETC.)
1																									
2																									
3																									
4			X	X	X	X	X	X	X	X	60mm														Caída de árboles en
5																									sector [illegible]
6										X	11mm														
7																									
8							X	X	X	X	X	11mm													
9					X	X	X	X	X	X	20mm														Rebalses de aguas
10					X	X	X	X	X	X	11mm														sobre el camino
11																									
12																									
13																									
14																									
15								X	X	X	X	60mm													Rebalse de Cuneta en
16																									K= 210
17																									
18								X	10mm																
19																						X	X	20mm	
20			X	X	X	X	X	X	X	X	X	X	60mm												Caída de árboles
21																									en sector [illegible]
22													X	10mm											
23				X	X	X	X	X	20mm																
24			X	X	X	X	5mm																		
25																									
26															X	X	X	7mm							
27	X	10mm																							
28							X	10mm																	
29																									
30							X	X	X	X	X	X	X	80mm											Rebalse agua [illegible]
31																	X	5mm							

X REGISTRO DE LLUVIA SIN DATOS DE PRECIPITACION
NUM REGISTRO DE LAS LLUVIAS CON DATOS DE PRECIPITACION

It is recommendable to record the rain fall every hour basically. But, because the Micro-empresas were not be able to engage themselves in the rain gauges at all time, a symbol "x" was marked when rain fall recognized and record total rain fall at the end of a series of rain fall.

1 EARLY WARNING FOR WIDE AREA BY PRECIPITATION MONITORING

1.2 ALERT LEVEL

The relation between the precipitation and disasters are not clear since the precipitation data is not accumulated so much in Bolivia.

Generally in Japan, when the rainfall intensity is over 20mm/hour or the integrated precipitation is over 100mm, the danger of slope disasters becomes higher. Bolivia can follow the Japan's alert level in wet area, and alert level should be lower in dry area as shown in Table 1.2.

Table 1.2 Criteria and Actions on Alert Levels by Precipitation Monitoring

Alert Level		Criteria (Wet Area)	Criteria (Dry Area)
Alert Level 1	Integrated Precipitation	> 100 mm, or	> 50 mm, or
	Rainfall Intensity	> 20 mm/hour	> 10 mm/hour
Alert Level 2	Integrated Precipitation	> 200 mm, or	> 100 mm, or
	Rainfall Intensity	> 40 mm/hour	> 20 mm/hour
Alert Level 3	Integrated Precipitation	> 250 mm, or	> 150 mm, or
	Rainfall Intensity	> 50 mm/hour	> 30 mm/hour

The Micro-empresas shall issue the alert with their precipitation observation based on the criteria of alert level. The Micro-empresas, the Supervisors and ABC Regional Offices will take necessary actions based on the each alert level as mentioned in Section 1.3.

After one year from the start of this monitoring system in the nation, the precipitation data of the year in the nation can be obtained, and the alert levels and the areas of dry /wet can be reconsidered and be more accurate. With experiences of disasters in the year, the relations between disasters and the precipitation can be obtained and this relation could contribute to study of disasters.

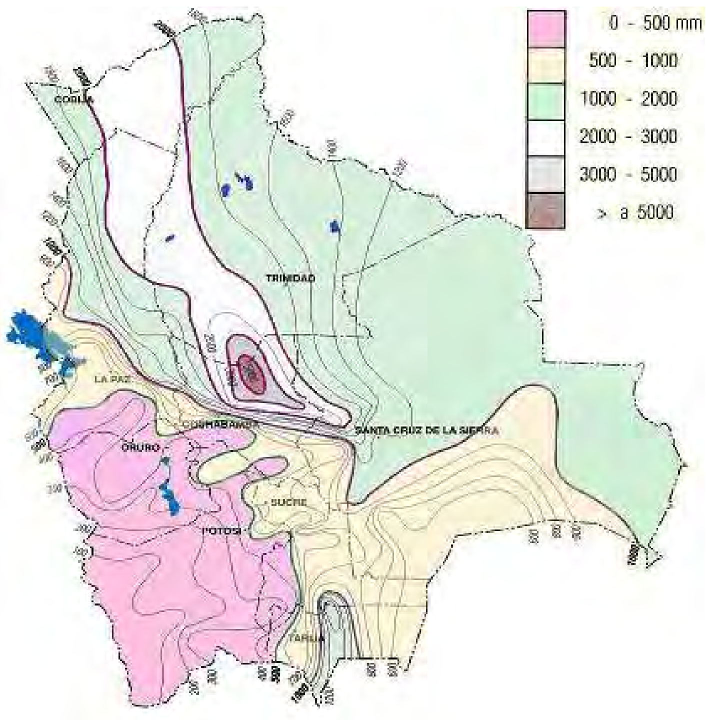


Figure 1.2 Isohyet Map of Bolivia

1 EARLY WARNING FOR WIDE AREA BY PRECIPITATION MONITORING

1.3 CORRESPONDENCE FOR EMERGENCY (PRE-DISASTER)

Actions to be taken on prevention stage (pre-disaster) will be realized according to 3 emergency levels. These levels will be initially based on pluvial precipitation of the Micro-empresas section.

The actions shall be taken as follows based on the alert levels.

Table 1.3 Criteria and Actions on Alert Levels

Alert Level	Criteria (wet area)	Criteria (wet area)	Summary of Actions
Alert Level 1	> 100 mm, or > 20 mm/hour	> 50 mm, or > 10 mm/hour	ME: patrol to the area, inform to SV, SV: inform to SRO
Alert Level 2	> 200 mm, or > 40 mm/hour	> 100 mm, or > 20 mm/hour	ME: inform to SV, SV: patrol along critical section, inform to SRO
Alert Level 3	> 250 mm, or > 50 mm/hour	> 150 mm, or > 30 mm/hour	Close the road of the area

ME: Micro-empresas, SV : Supervisor, SRO : ABC Regional Office

Alert Level 1

1) Alert Level 1 will be activate when the precipitation reaches the alert level in wide area as shown in Table 1.3.
2) The Micro-empresas responsible for data registration of precipitation shall be the first to communicate the alert to the Supervisor and ask for the activation of Alert Level 1.
3) Depending on the critical section of the road, the observation by the Micro-empresas shall be realized with the objective of verify the state of the road and the transitability.
4) The Micro-empresas shall continue the monitoring work on the rain gauge to the Alert Level 2 and the Alert Level 3 until rain stops.
5) If the rain has stopped over three hours, the Micro-empresas shall communicate this to the Supervisor to deactivate the Alert Level 1.

Alert Level 2

1) Alert Level 2 will be activate when the precipitation reaches the alert level in wide area as shown in Table 1.3.
2) In case that precipitation continues and reach to the alert level 2, the Micro-empresas shall communicate to the Supervisor for activation of Alert Level 2.
3) Once the emergency alert has being activated, the Supervisor will communicate the maintenance chief and the regional chief the conditions and location of the emergency.
4) The Supervisor will realize an emergency inspection on the affected section, verify the slope and road conditions, and communicate the conditions to the maintenance chief.
5) If the rain has stopped over three hours, the Supervisor will communicate deactivate the alert level to the maintenance chief.

1 EARLY WARNING FOR WIDE AREA BY PRECIPITATION MONITORING

Alert Level 3

1) Alert Level 3 will be activate when the precipitation reaches the alert level in wide area as shown in Table 1.3.
2) The Supervisor shall communicate the emergency Alert Level 3 to the maintenance chief and the regional chief.
3) When the Alert Level 3 is activated, the section will be closed by the Supervisor under advice of ABC Regional Office.
4) The maintenance chief and the regional chief shall inform to the related organs as follows.
   - Advice to the control toll points the emergency situation.
   - Installation of preventive and informative signs.
   - Advice to the police transit department the closure of the section
   - Advice to users the closure of the section for a certain period.
   - Information about road relocation or alternative road.
   - Coordinate emergency tasks between the Micro-empresas, police, toll points and local communities.
5) The following action shall be taken with the section closed.
   - The Micro-empresa shall install warning and informative signs.
   - The Supervisor and ABC shall find the alternative road or road relocation.
   - The location shall be rehabilitate the section as soon as possible.
   - The Supervisor shall inspect the affected section.
   - ABC shall obtain equipment and workers for emergency measures and start the construction and rehabilitation works of the affected section.
   - The Supervisor shall stay on the emergency section until the road is fixed
   - ABC shall start the preparation of the design and approval on the countermeasures.
   - ABC shall star the preparation of economical resources for rehabilitation.
6) If the rain has stopped over three hours, the Supervisor shall verify the section there is no disaster occurred and the road is in safe condition.
7) If the Supervisor confirm the road is in safe condition, he shall communicate deactivate the alert level to the maintenance chief and open the section of the road.

2 EARLY WARNING AT HIGH RISK SPOTS

2.1 SELECTION OF HIGH RISK SPOT

The instruments shall be installed and monitored at critical slopes in order to know speed and magnitude of landslides. This monitoring system can be the early warning for the critical spots besides offering the information for the designing of countermeasures, while the precipitation monitoring system is the early warning for the wide area.

Actual selection of location and instrumentation shall be decided by experienced geotechnical engineer with consultation with the Supervisor. It is important that all instruments can warn to the road management office as soon as they detect the warning level of movement or signal through monitoring operator or the automatic information system which is the part of automatic measurement system. The automatic measurement system processes all monitoring work such as data collection, data storage and data transportation automatically. The automatic measurement system is introduced in the attachment of this guide.

Location where is monitored is selected in the Road Disaster Inventory Survey and the Detailed Inspection in Guide I Inspection and Plan or the Detailed Inspection in Guide II Ordinary Maintenance.

Early Warning System which makes best use of monitoring systems shall be installed at the slopes to defend the traffic from disasters until the completion of measure work. Table 2.1 might be good guide to decide, however, actual selection of instrumentation shall be done by experienced engineer. The automatic monitoring or manual monitoring. If the road is very important or the access is difficult, the automatic monitoring is recommendable.

2 EARLY WARNING AT HIGH RISK SPOTS

2.2 INSTRUMENTATION

Table 2.1 shows the instruments useful to get the information about disasters

Table 2.1 Instruments for Early Warning

Items	Instrument	Notes	Applicable Disaster
Rock Fall Detection	Rock Fall Detector	For direct information of actual fall or failure occurrence.	Rock Fall Rock Mass Failure Debris Flow
Slope Surface Movement	Wire Extensometer Electro- Optical Distance Meter	For early warning based on large displacement exceeding the established standard criteria	Collapse Rock Fall Rock Mass Failure Landslide Embankment Failure
Slope Surface Behaviour	Crack Gauge Surface Tiltmeter	For getting information of accelerated change of the measured items (The standard criteria to be studied and determined for each slope.)	Collapse Rock Fall Rock Mass Failure Landslide Embankment Failure For Road Structure
Subsurface Movement	Borehole Inclinometer Borehole Extensometer	For getting information of accelerated change of the measured items (The standard criteria to be studied and determined for each slope.)	Landslide
Groundwater Level (Pore Pressure)	Water Level Meter Piezometer	For getting information of change of water level or pore pressure (The standard criteria to be studied and determined for each slope.)	Landslide Collapse
Precipitation	Rain Gage	For analysis of relation with other measurement result For traffic control	For all disasters

2 EARLY WARNING AT HIGH RISK SPOTS

2.3 ALERT LEVEL

Based on the actual wire extensometer monitoring on landslides in Japan, remaining time (Tr) to the failure (collapse) is expected by the speed of ground surface movement (ε). As a result of the above, the following analytical criteria of the wire extensometer have been generated in Japan.

Table 2.2 Criteria of Movement of Landslide (Wire Extensometer)

Alert Level	Criteria	Daily displacement (mm)	Monthly displacement (mm)
Precaution	Latent Change	$\geq 2 \times 10^{-2}$ mm	$\geq 5 \times 10^{-1}$ mm
Alert Level 1	Semi-Established Stage	$\geq 1 \times 10^{-1}$ mm	$\geq 2 \times 10^{0}$ mm
Alert Level 2	Established Stage	$\geq 1 \times 10^{0}$ mm	$\geq 1 \times 10^{1}$ mm
Alert Level 3	Urgent Stage	$\geq 2 \times 10^{1}$ mm	$\geq 5 \times 10^{2}$ mm

As shown above example, many data were accumulated in the study of slope disasters in Japan. Not only the wire extensometer data but also data of inclinometer, tiltmeter and so on are accumulated and studied in terms of the relation between disasters. Some standard criteria based on the monitoring result have been established in road management bodies or railway companies in Japan as shown in the attachment of this guide. However, in Bolivia, only the wire extensometer may be standard monitoring system for the early warning at the critical spot.

2.4 CORRESPONDENCE FOR EMERGENCY (PRE-DISASTER)

Actions to be taken on prevention stage (pre-disaster) will be realized according to 4 alert levels. These levels will be initially depending on the monitoring of the spot.

The actions shall be taken as follows based on the alert levels.

Table 2.3 Criteria and Actions on Alert Levels

Alert Level	Daily displacement (mm)	Monthly displacement (mm)	Summary of Actions
Precaution	$\geq 2 \times 10^{-2}$ mm	$\geq 5 \times 10^{-1}$ mm	OP: inform to SV,
Alert Level 1	$\geq 1 \times 10^{-1}$ mm	$\geq 2 \times 10^{0}$ mm	OP: inform to SV, increase frequency of the monitoring, SV: inspect the spot
Alert Level 2	$\geq 1 \times 10^{0}$ mm	$\geq 1 \times 10^{1}$ mm	OP: inform to SV, SV: inspect, watch the spot, stay at the spot, inform to SRO
Alert Level 3	$\geq 2 \times 10^{1}$ mm	$\geq 5 \times 10^{2}$ mm	Close the road at the spot

OP: Monitoring Operator, SV : Supervisor, SRO : ABC Regional Office

Precaution

1) The movement of monitoring reaches the alert level in spot as shown in Table 2.3.
2) The monitoring operator inform the Precaution to the Supervisor

Alert Level 1

1) Alert Level 1 will be activated when the movement of monitoring reaches the alert level at the spot as shown in Table 2.3.

2 EARLY WARNING AT HIGH RISK SPOTS

2) The monitoring operator at the spot shall be the first to communicate the alert to the Supervisor and ask for the activation of Alert Level 1.
3) The Supervisor shall verify the state of the spot and the safe and transitability of the road.
4) The monitoring operator shall continue the monitoring work more frequently.

Alert Level 2

1) Alert Level 2 will be activate when the movement of monitoring reaches the alert level at the spot as shown in Table 2.3.
2) The monitoring operator shall communicate to the Supervisor for activation of Alert Level 2.
3) Once the emergency alert has being activated, the Supervisor will communicate the maintenance chief and the regional chief the conditions and location of the emergency.
4) The Supervisor will realize an emergency inspection on the spot, verify the slope and road conditions, and communicate the conditions to the maintenance chief.
5) The Supervisor under authorization of maintenance chief shall stay at the spot.

Alert Level 3

1) Alert Level 3 will be activate when the movement of monitoring reaches the alert level in spot as shown in Table 2.3.
2) The Supervisor shall communicate the emergency alert level 3 to the maintenance chief and the regional chief.
3) When the Alert Level 3 is activated, the highway at the spot shall be closed by the Supervisor under advice of ABC Regional Office.
4) The maintenance chief and the regional chief shall inform to the related organs as follows.
   - Advice to the control toll points the emergency situation.
   - Installation of preventive and informative signs.
   - Advice to the police transit department the closure of the section
   - Advice to users the closure of the section for a certain period.
   - Information about road relocation or alternative road.
   - Coordinate emergency tasks between the Micro-empresas, police, toll points and local communities.
5) With the section closed, the following action shall be taken.
   - The Micro-empresa will install warning and informative signs.
   - The Supervisor and ABC will find the alternative road or road relocation.
   - The location should be rehabilitate the section as soon as possible.
   - The Supervisor must inspect the affected section.
   - ABC will obtain equipment and workers for emergency measures and start the construction and rehabilitation works of the affected section.
   - The Supervisor must stay on the emergency section until the road is fixed
   - ABC will start the preparation of the design and approval on the countermeasures.
   - ABC will star the preparation of economical resources for rehabilitation.
6) The section will be open when deactivate the alert level after the supervisors verification that the road is in safe condition.

2 EARLY WARNING AT HIGH RISK SPOTS

APPENDIX III-1 EARLY WARNING

(FOR FUTURE REFERENCE)

The contents of this appendix are excerpted from the following publication.

JICA, March 2002. Guide III: Guide to Early Warning and Site Investigation.
The Study on Slope Disaster Management for Federal Roads in Malaysia.

APPENDIX III-1 EARLY WARNING

In this guide, simple and low cost of monitoring systems are recommended. This appendix introduces more complex early warning system and criteria for further studies and in future. And also, it introduces instrumentations for monitoring of slope disasters.

A1-1 EARLY WARNING FOR WIDE AREA

(1) Rainfall Monitoring Stations

It is the fact that one of the main factors that could lead the slope disasters is the rainfall. What kind of rainfall may influence the disaster is concerned with the topographic and the geological conditions at the respective areas. According to various peculiar conditions, the drizzling rain in long period or the heavy rain in short period, to say nothing of the heavy rain in long period, might be a trigger of the disasters. As to the road disaster management, not only prevention works against the dangerous slopes but the reliable rainfall observation and appropriate measures for the traffic control based on the rainfall data is indispensable. Rainfall Monitoring should be useful for comprehensive road management such as the traffic control under heavy rain. The traffic control under heavy rain is based on the experimental fact or statistical knowledge that the number of slope failures increases remarkably when the amount of rainfall exceeds a certain value.

General standard for an arrangement of the rainfall observation in Japan is that one station covers at least an area of 50 km^2. Currently, the average area covered by one station is an area of 17 km^2, and many observation stations with the radar technology have been installed to cover throughout the country. The data obtained from the fixed point and the radar observation are complemented each other and analysed effectively. It contributes to reliability of the data, supply of the data at short intervals and in an instant. Furthermore, the additional observation stations have been installed suitably for the dangerous areas in accordance with the importance of the traffic situations.

Bolivia has rainfall monitoring system already in SENAMI. It obviously is not enough to manage the national highways. It is recommendable for primary stage of road disaster prevention program to set simplified rain gauge at micro-empresas' stations or supervisors' stations for the national road disaster management as mentioned in this guide. The micro-empresas and the supervisors is going to issue the alert based on their rain observation.

Simultaneously, with regard to the road disaster management, how the traffic control can be conducted effectively might be one of the key issues. As for the effective traffic control, there are two important prerequisites to be considered. One is a settlement of the dangerous rainfall index, and the other is the timely and suitable measures according to the index. In order to examine the both items, the observation performed on daily basis would be insufficient to provide effective information. Consequently, the observation of the hourly rainfall is highly required.

In addition, the observation by automatic rain gauge instruments with the data logger is appeared to be reasonable and recommended for the fixed point observation due to consideration of reliability of the data, the necessity of the hourly rainfall data and the cost of installation including the equipment cost.

APPENDIX III-1 EARLY WARNING

(2) Criteria

Empirically we know that the risk of slope disaster increase in heavy rain in Bolivia.

The value of rainfall criteria for Early Warning shall be finalized in accordance with various conditions of each national road section as follows, because the warning shall be wide area and effect to various people.

As the first step of Early Waning, the criteria in Bolivia could follow the one of Japan. The method JRs (Japan Railway)and JH (Japan Highway) adopts shown in Figures A1-1.3 and A1-1.4 are not complicated and could be applicable In Bolivia. However, the rainfall pattern in Bolivia may be very different from it in Japan. It is strongly recommended to accumulate the rainfall data and study the relation between the rainfall and disasters. The criteria should be improved based on it.

Tentatively this guide recommend for Bolivia Road Management to adopts JH criteria to control traffic in heavy rain.

The several methods to evaluate the rain fall in terms of the relation between disasters such as collapse, debris flow have been proposed and applied as follows in Japan.

a) Hourly Rainfall Method

Hourly rainfall can be thought to represent well for the rainfall intensity indicator. To be a good indicator causing shallow slope failure (generally <1m depth)

b) Accumulated Rainfall Method

Accumulated rainfall (summation of precedent rain without break) reflects better on collapse or landslide than heavy rain of short term.

R = ∑Ri (Ri : hourly rainfall at i hours before)
If the rainfall has been stopped for three ours Ri shall be 0 .

This is most simple method applicable to urgent evaluation and is widely used in road management in mountain area in Japan. This method is more reliable than Hourly Rainfall Method, however, it has still have some error to predict the disasters.

c) Combined Method of Hourly Rainfall and Accumulated Rainfall

Combined of methods of a) and b) is more reliable than the single application.
This method is adopted by Japan Railway (Figure A1-1.1).

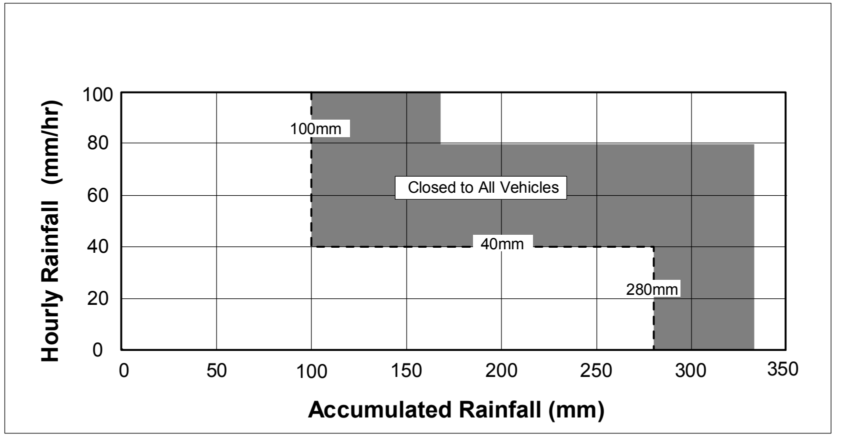


Figure A1-1.1 Recommended Criteria for Traffic Control

APPENDIX III-1 EARLY WARNING

d) Effective Rainfall Method

Effective rainfall is defined as the accumulated rainfall with attenuation by run-off effect of precedent rain. It is explained by following formula.

$$R = \sum AiRi$$

(Ai = 0.5 i/T, T : half life of water level in the ground (depend on geology))

This method is adopted by many road administrator Japan, including expressway and federal road.

e) Water Storage in-Soil Method

Change of water volume in the soil is evaluated using tank model analysis.

Being adopted in special program aerial disaster warning in use of weather forecast radar network.

Effective Rain Fall Method and Combined Method are common in road management and railway management. The followings are example of rainfall evaluation based on two methods.

(3) Example of Criteria

a) Effective Rain Fall Method by Road Management Japan

To decide a criteria by this method, the rainfall data and the disaster record of the region in last 15 years shall be obtained. The relation between the rainfall and the disaster has be cleared based on the 15 years data and graphed as shown on Figure below. The exampled shown on Figure shows that the disasters were increased in 80 – 130 mm effective rainfall. The 80 mm of effective rainfall could be decided as criteria rainfall by this result.

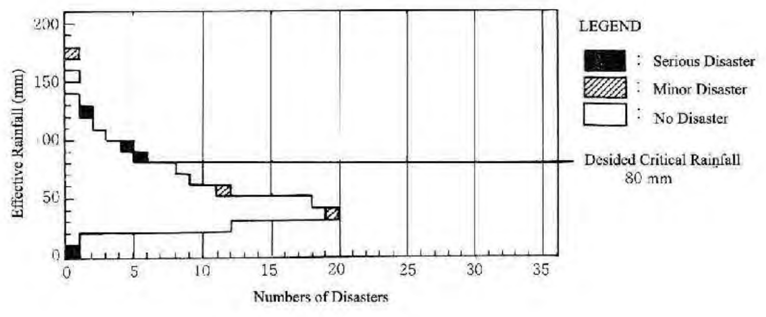


Figure A1-1.2 Effective Rainfall with Disasters Last 15 years (Ministry of Construction, Japan)

b) Combined Method of Hourly Rainfall and Accumulated Rainfall

Japan Railway (JR) is using the following graph to control train system. Figure A1-1.3 shows that the example of train control based on rainfall by Japan Railways. It is based on accumulated rainfall and hourly rainfall.

APPENDIX III-1 EARLY WARNING

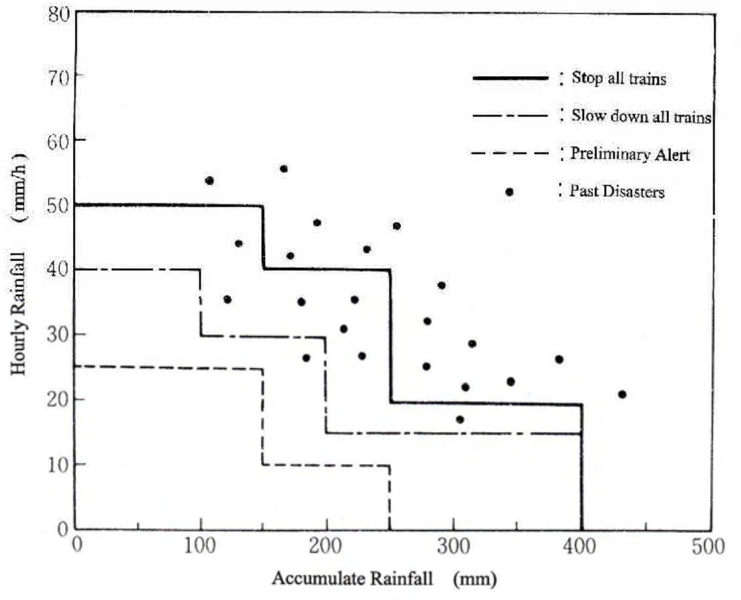


Figure A1-1.3 Train Control Based on Rainfall by Japan Railways

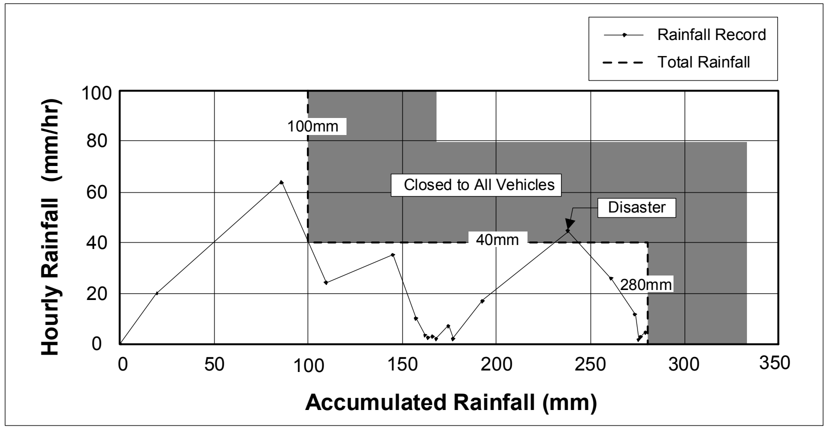


Figure A1-1.4 Train Control Base on Rainfall by Japan Highway Corporation

Japan Highway Corporation (JH) is using the following graph to control traffic. Figure A1-1.4 shows that the example of train control based on rainfall by JH. It is based on accumulated rainfall and hourly rainfall. The shadowed area in the graph is to be considered as critical stage for the highway.

APPENDIX III-1 EARLY WARNING

(4) Instruments

Arrangement

The road concerned is divided into sections indicating approximately even rainfall condition, and one rainfall observatory is provided in each section. When such division is difficult, the district including the road concerned is divided into sections, each having the approximate area of 50 km^2, and one observatory is provided in each of these sections.

Selection of the location

The location of provision to be selected on the map should be as follows:

i) Location where the wind direction and velocity do not show any singular values because of narrow topography
ii) Location without excessive exposure to or shield from wind, and other singular rainfall condition

The location should as a rule comply with the following conditions:

i) Open land with an approximately 10 m wide or squarer, with limited localized change of air flow
ii) No possibility of inundation
iii) Convenient for observation and patrol inspection
iv) No attack from wild lives, etc.

Instrument

Instruments for observation of rainfall should comply with the authorization rules.

i) Inlet
The standard diameter of inlet of rainfall gauge is 20 cm, and the inlet should be provided horizontally.

ii) Sign
The sign describing the location ID, name of installer, year/month/day of installation, latitude, longitude, altitude, and name of observation personnel should be provided near the installed instrument, with the fence provided around the location.

iii) Register
When an observatory is provided or observation is contracted to the existing observatory, the personnel to perform rainfall survey should prepare the register of rainfall observatories and attached location map. The register should describe the location of observatories and data of facility construction.

Table A1-1.1 shows rain gauge instruments commonly used

Table A1-1.1 Installed Types of Rain Gauge Instruments

Type	Remarks
Manual rain gauge	Rainfall are observed and recorded manually.
Semi-automatic rain gauge	Rainfall are Observed automatically and recorded using graphical recorder.
Automatic rain gauge	Rainfall are observed automatically and recorded using data acquisition unit (data logger etc.).

APPENDIX III-1 EARLY WARNING

Observation Personnel

For observation, the agency to perform survey of rainfall should select the eligible personnel complying with the following conditions and contract the survey to those personnel:

i) Personnel who can be engaged in observation at given times continuously over a long period
ii) Personnel who have the knowledge necessary for handling of self-registering instrument when the observatory is equipped with self-registering instrument

The agency in charge of rainfall observation should develop directions for observation and observation personnel and deliver them to those performing observation.

Directives concerning observation should contain the following matters:

i) Objective and meaning of observation
ii) How to use observation facilities
iii) How to handle observation instruments
iv) Cautions for implementation of observation
v) Standard for ad-hoc observation
vi) Other necessary matters
vii) Directives for observation personnel should contain the following matters:
viii) How to handle observation record and to report the observation results
ix) Procedure for newly-appointment, resignation, or delegation of observation personnel
x) Storage and turn-over of properties
xi) Other necessary matters

Patrol check

In order to confirm that observation is implemented without fail, patrol is made among observatories in the specified timing, checking the operation condition of instruments. Periodical inspection at least once a month and overall inspection at least once a year should be made on observation instruments and facilities.

Observation with self-registering rainfall gauge

During observation with the self-registering rainfall gauge, either the self-registering media is replaced or record reading is made.

Filing of data

Rainfall data is filed according to the specified form.

Job assignment should be established beforehand among persons concerned to ensure smooth data filing operation.

Verification

Prior to publication of data, thorough verification should be made in each stage of filing, ensuring appropriateness of numerical values to be published. Any ambiguities should be checked if found after verification. Any detected error should be corrected according to the specified procedure.

APPENDIX III-1 EARLY WARNING

A1-2 EARLY WARNING AT HIGH RISK SLOPES

(1) Instrumentation

A threat or a sign that something bad on slope must be known by instrumentation and monitoring on the slope to defend the traffic from disasters.

The instruments shall be installed at slopes are determined based on the expected disaster types.

For the purpose of road maintenance, following action should be required to decide the slope to be monitored. The measures shall be taken against the high risk slopes which are selected by slope inspection as soon as possible. However, the measure work could not be done on all high risk slope so soon. Early Warning System which makes best use of monitoring systems shall be installed at the slopes to defend the traffic from disasters until the completion of measure work.

1) Pick up high risk slopes by Slope Inspection
2) Select the slope in the high risk slopes to be monitored based on critical stage, road importance
3) Decide monitoring method, automatic monitoring or manual monitoring. If the road is very important or the access is difficult, the automatic monitoring is recommendable.
4) Decide instruments. Table A1-2.1 might be good guide to decide, however, actual selection of instrumentation shall be done by experienced engineers.

It is important that all instruments as the warning system can warn to the supervisors or the road management offices as soon as they detect the warning level of any movement or signal through monitoring operator or automatic information system.

The automatic information system could be the part of automatic measurement system, and processes all monitoring works such as data collection, data storage and data transportation automatically.

Automatic measurement system should be planned taking into account the deformation condition of slope, objective of measurement, measurement items, measurement frequency, layout and quantity of instruments, type of instrument, maintenance of instrument, and site condition. Basically the system consists of a sensor block, data recorder, control block, data processing block, transmission block, alarm unit, surge protector, and power supply system.

APPENDIX III-1 EARLY WARNING

Table A1-2.1 Instruments for Early Warning

Items	Instrument	Notes	Applicable Disaster
Rock Fall Detection	Rock Fall Detector	For direct information of actual fall or failure occurrence.	Rock Fall Rock Mass Failure Debris Flow
Slope Surface Movement	Wire Extensometer Electro- Optical Distance Meter	For early warning based on large displacement exceeding the established standard criteria	Collapse Rock Fall Rock Mass Failure Landslide Embankment Failure
Slope Surface Behaviour	Crack Gauge Surface Tiltmeter	For getting information of accelerated change of the measured items (The standard criteria to be studied and determined for each slope.)	Collapse Rock Fall Rock Mass Failure Landslide Embankment Failure For Road Structure
Subsurface Movement	Borehole Inclinometer Borehole Extensometer	For getting information of accelerated change of the measured items (The standard criteria to be studied and determined for each slope.)	Landslide
Groundwater Level (Pore Pressure)	Water Level Meter Piezometer	For getting information of change of water level or pore pressure (The standard criteria to be studied and determined for each slope.)	Landslide Collapse
Rainfall	Rain Gage	For analysis of relation with other measurement result For traffic control	For all disasters

(2) Criteria

Rainfall, geology and vegetation in Bolivia are different from them in Japan. It is not sure that the standard criteria can be applied in Bolivia. It is recommendable to accumulate the monitoring result and study the ground movement at slope disaster like Figure A1-1.1. Until accumulate the data, Table A1-2.2 could be applied as the criteria in Bolivia.

Actual selection instrumentation and location shall be decided by experienced geotechnical engineer to consider

a) Level of risk
b) Level of emergency
c) Importance of the road
d) Distance from the road management office

Standard Criteria based on Ground Movement

By the careful analysis of monitoring result, we could know how critical the slope is.

Figure III-1.5 shows the example of the prediction curve which is based on actual wire extensometer monitoring on landslides in Japan. As shown in the figure, remaining time Tr to the failure is expected by the speed of ground surface movement ε using following formula.

$$\log_{10} Ts = 2.3 - 0.9 \log_{10} \varepsilon$$

APPENDIX III-1 EARLY WARNING

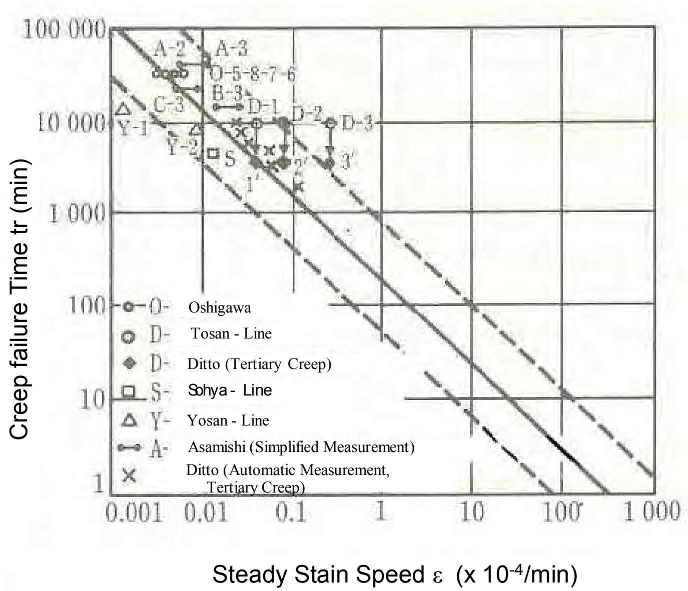


Figure A1-1.1 Time to Slope Failure – Strain Speed (Wire Extensometer)
(Strain : conversion to 10 m long wire)

As a result of the above, the following analytical criteria of wire extensometer has been generated and common in Japan.

Table A1-2.2 Example Standard Criteria of the Wire Extensometer

Criteria	Daily displacement (mm)	Monthly displacement (mm)
Urgent Stage	2×10^{1} or more	5×10^{2} or more
Established Stage	1×10^{0} or more	1×10^{1} or more
Semi-Established Stage	1×10^{-1} or more	2×10^{0} or more
Latent change	2×10^{-2} or more	5×10^{-1} or more

As shown above example, many data were accumulated in the study of slope disasters in Japan. Not only the wire extensometer data but also data of inclinometer, tiltmeter and so on are accumulated and studied in terms of the relation between disasters. Some standard criteria based on the monitoring results have been established in road management bodies or railway companies in Japan.

Table A1-2.2 shows the standard criteria for road disaster created by The Highway Study Committee in Japan. There are four levels of warning based on the monitoring results. Other bodies issued different criteria, but they may not much different from Table A1-2.3.

APPENDIX III-1 EARLY WARNING

Table A1-2.3 Standard Criteria (Except Rain Gauge)

Warning Level		Level 1	Level 2	Level 3	Level 4
Action		Site Inspection, Frequent Monitoring	Call a Committee	Preliminary Alert, Emergency Measure	Danger Level, Evacuation
Extensometer Borehole Extensometer Distance Meter	Ground Surface Displacement Velocity	>10 mm / 30days	5-50 mm / 5days	10-100 mm /day	>100 mm /day
Inclinometer	Displacement Velocity at Slip Surface	>1 mm /10days	5-50 mm /5days	-	-
Tiltmeter	Tilting Velocity	10-50 seconds / 10days	-	-	-
Rock Fall Detector	Rack Fall Detect	Detect any rock fall	-	-	-

The rainfall monitoring is more useful for the wide area, however from the economical view, it is not recommendable to install one rain gage at one slope because rainfall data could represent certain area around rain gauge. The rainfall monitoring shall be used for the traffic control in wide area.

The groundwater level is usually very related with rainfall. Theoretically when the ground water level is higher, the slope becomes unstable. The groundwater level in borehole at which landslide begins to be active is defined as the critical water level. Figure A1-1.2 shows an example comparison between the groundwater level and daily movement. The critical water level is estimated to be around GL-8 m in the figure.

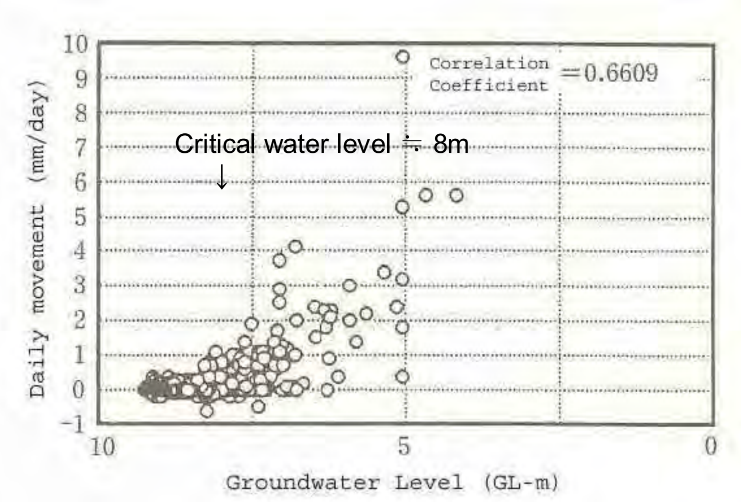


Figure A1-1.2 Typical Comparison between the Groundwater Level and Daily Movement

APPENDIX III-1 EARLY WARNING

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

(FOR FUTURE REFERENCE)

The contents of this appendix are excerpted from the following publication.

JICA, March 2002. Guide III: Guide to Early Warning and Site Investigation.
The Study on Slope Disaster Management for Federal Roads in Malaysia.

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

In this chapter, the standard instrumentation in Early Warning System and Site Investigation is introduced. Specific principle and procedure of each method are described in ASTM, BS and technical documents. This chapter describes mainly considerations for implementation. For the measurement system, selection and design of each component should be made with due consideration of the following evaluation items.

Table A2-0.1 Evaluation Standard of the Measurement System

Evaluation Item	Standard
Adaptability	Free setting of measurement interval Time-series indication of measurement values Compatibility with power supply Matching of accuracies between measurement equipment and system
Reliability	Function to protect each equipment against indirect lightning stroke Backup function in case of power failure
Convenience	Addition of sensor and local station as required by the situation while keeping the present state of power supply and data transmission equipment Rapid transmission of measurement result
Weather resistance	Compatibility with particularity, such as a tropical area, etc. Superior waterproof and moisture resistance Normal operation under expected temperature conditions
Maintainability	Less inspection frequency Short-term inspection
Economy	Inexpensive system

The various kinds of instruments introduced in this guide are listed in Table A2-0.2. Suitable one should be selected by experienced engineer based on the site condition or management condition.

Table A2-0.2 Instruments for Early Warning System

Type	Name of Instrument
Surface Fluctuation	Wire Extensometer Tiltmeter (Water Tube Type) Tiltmeter (Electric Type) Site Survey GPS Strain Gauge Crack Gauge (Manual) Crack Gauge (Automatic) Rock Fall Detector Slope Collapse Detector Embankment Collapse Detector
Subsurface Fluctuation	Inclinometer Pipe Strain Gauge Multipoint Borehole Extensometer In-place Inclinometer Acoustic Emission
Groundwater Fluctuation	Water Standpipe Piezometer
Other New Method	Three-Dimensional Shear Displacementmeter Fibre-optic Sensor

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

A2-1 MEASUREMENT OF SURFACE FLUCTUATION

A2-1.1 Wire Extensometer

(1) Instrument

The wire extensometer is used mainly to understand the movement of landslide activities. If landslide becomes active, with cracks appearing in the ground surface, the wire extensometer is installed and observed to determine development of crack and movement of landslide soil mass.

As shown in Figure A2-1.2, piles are provided on both ends of the area concerned. The instrument is provided to one of them while the invar wire (nickel-copper wire with low coefficient of thermal expansion) is spread from the other one. This wire crosses over the area concerned and is connected to the instrument. The invar wire on the pile side is fixed while that on the instrument side is connected to the wire wound on a drum. The drum of extensometer has the recording form, on which a recording pen that moves parallel to the drum rotation axis plots the time-displacement graph.

The actual accuracy is about 1 mm, so that it is difficult to detect any latent landslide activity. Besides, this instrument is almost insensitive to the movement in a direction nearly normal to the elongation direction. When the instrument has to be installed on the side of landslide, it is necessary to bring the invar wire as near as possible to the landslide movement direction.

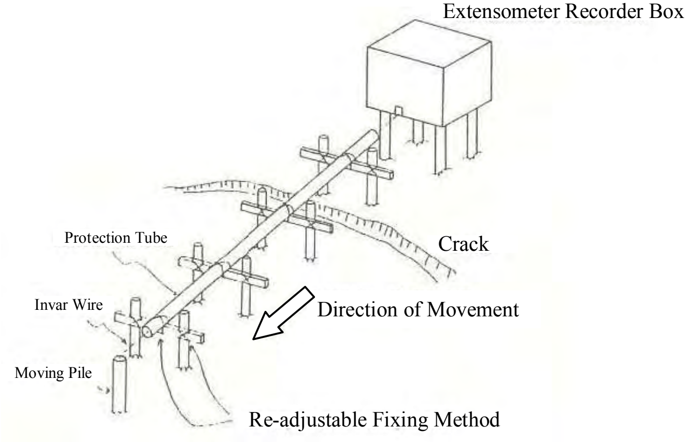


Figure A2-1.1 Graphical Installation Diagram of Wire Extensometer

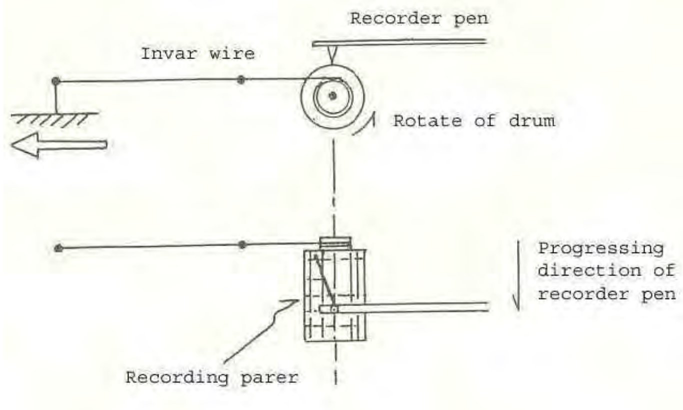


Figure A2-1.2 Diagram Explaining the Principle of Wire Extensometer

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

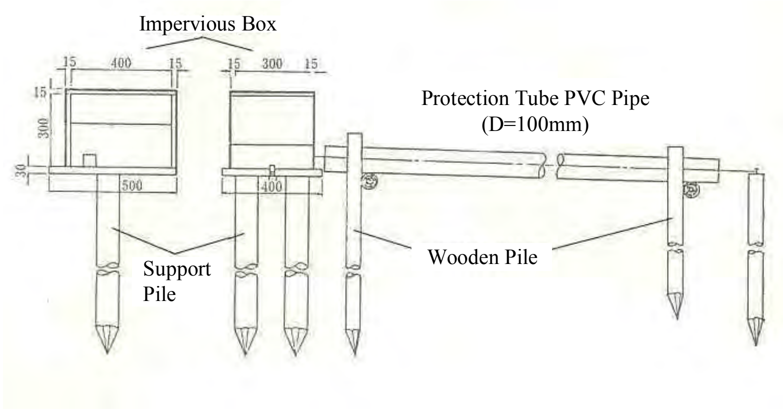


Figure A2-1.3 Typical Construction Diagram of Box Housing the Wire Extensometer

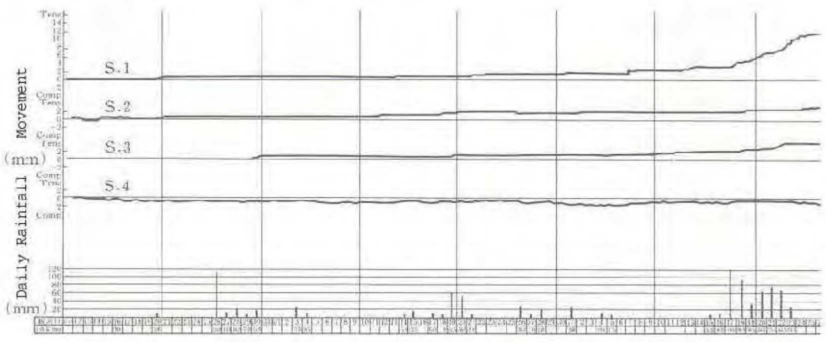


Figure A2-1.4 Result of Measurement with an Installed Extensometer

(2) Installation method

i) The direction to install the wire extensometer should agree with the movement direction of landslide as much as possible. As shown in (a) of Figure A2-1.5, this instrument is generally installed on both sides of a primary scarp. A shifting pile should not be provided in a location with high settlement.

ii) Figure A2-1.5, (b) shows observation of the relative movement of blocked landslide soil mass on both sides of crack in the landslide area. Installation of instruments consecutively as shown in (c) enables observation of the absolute movement of the landslide as a whole, difference in movement of blocked soil mass, and time lag of movement among blocks.

iii) Figure A2-1.5, (b) shows determination of the movement vector when the movement direction is not known.

iv) As the invar wire is readily bent, a levelling string is provided between two points. Checking should be made whether the gradient is too steep, the height of support pile of invar wire protective tube is unstable, or exuberance of vegetation in the neighbourhood presents hindrance to observation. The distance between two points is 10 m, maximum 15 m.

v) The invar wire protective tube is used to prevent recording of abnormal values through shielding from direct sunshine, wind, plants and animals, and other influences. Normally, about 100 mm dia. PVC pipe is used. After installation of the pipe, the levelling line should be replaced by the invar wire.

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

vi) The borehole extensometer shown in Figure A2-1.5 is used to observe the movement on the slide surface position by fixing the end of invar wire to the bedrock in the bottom of borehole.

vii) The extensometer could be used for monitor the rock mass failure as shown in Figure A2-1.5.

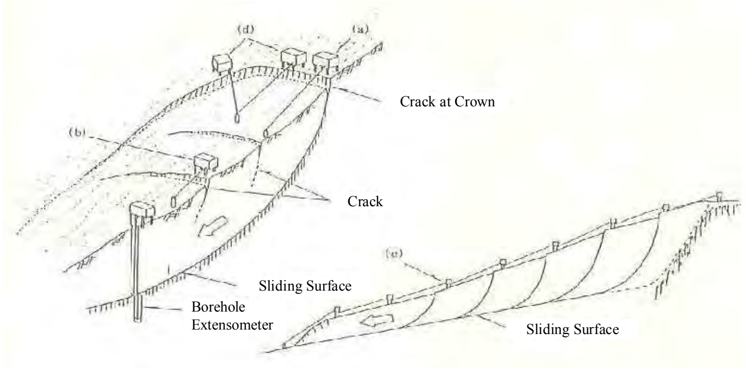


Figure A2-1.5 Typical Installation of Wire Extensometer

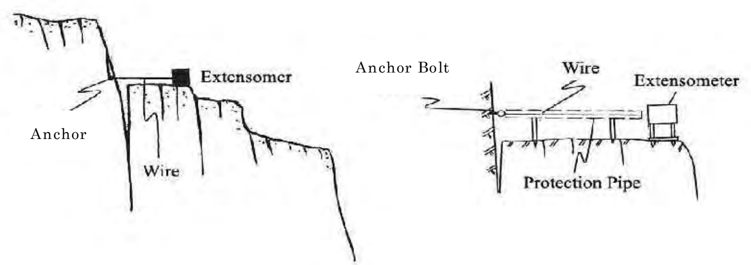


Figure A2-1.6 Wire Extensometer Monitoring on Rock Mass Failure

(3) Measurement, maintenance, and inspection

i) At start of recording, the recording pen is set at that time point and the date/time of start, the name of location, and other necessary data are entered in the recording paper.

ii) When the invar wire protective tube is bent contacting the invar wire, the daily expansion/contraction change may be recorded according to deformation of the protective tube. In this case, the tube should be corrected to keep a space from the invar wire.

iii) When any sudden elongation or discontinuous noise of expansion/contraction is recorded, pull-out and dislodgement of the tube, contact of twig with the invar wire after storm, and other causes may be considered. The area around the invar wire should be checked, and the tube should be repaired and surrounding trees removed.

iv) In case of loss of record, defective recording pen, over-stroke or metal fatigue cutting of invar wire, battery down of the clock, etc. may be considered. Regular inspection/maintenance should be made at least once a month.

(4) Data filing and judgment

i) Data from observation is filed in the form of the time-movement curve, with the data, daily rainfall, and groundwater level around the observation point included.

ii) Determination is made on landslide condition, such as the movement of landslide soil mass, movement velocity, mutual relationship between landslide blocks, and movement direction, from the time-movement curve.

iii) Enquiry is made into the relationship between the rainfall, groundwater level, etc. and the movement condition to review the landslide mechanism.

iv) When the movement is accelerated, with imminent possibility of landslide, the collapse time is predicted.

A2-1.2 Tiltmeter

The tiltmeter is used mainly to determine inclination change of the ground surface. Representative sensors used in this inclinometer are of a water tube, servo type accelerometer, operational transformer, and strain gauge type. The water tube type is used for manual measurement. Others are electric and used for automatic observation.

The foundation bed for tiltmeter should be firm with foundation piles driven, so as to avoid various noises caused by change in the surface layer due to drying, wetting, and frost heave as well as settlement of surface soil under the weight of observation personnel and wild life. (Figure A2-1.7)

It should be noted that the tiltmeter is extremely sensitive to landslide with large change amount, exceeding the observation range too early. In order to judge the change of inclination, observation results are filed in the form of the cumulative inclination changes by observation direction, cumulative inclination change – direction diagram, daily inclination change diagram, and daily inclination change – direction diagram. It is difficult to determine the scale of disaster and the pattern of change only from the observation results of tiltmeter. Results from other investigations should also be taken into account to achieve overall judgment.

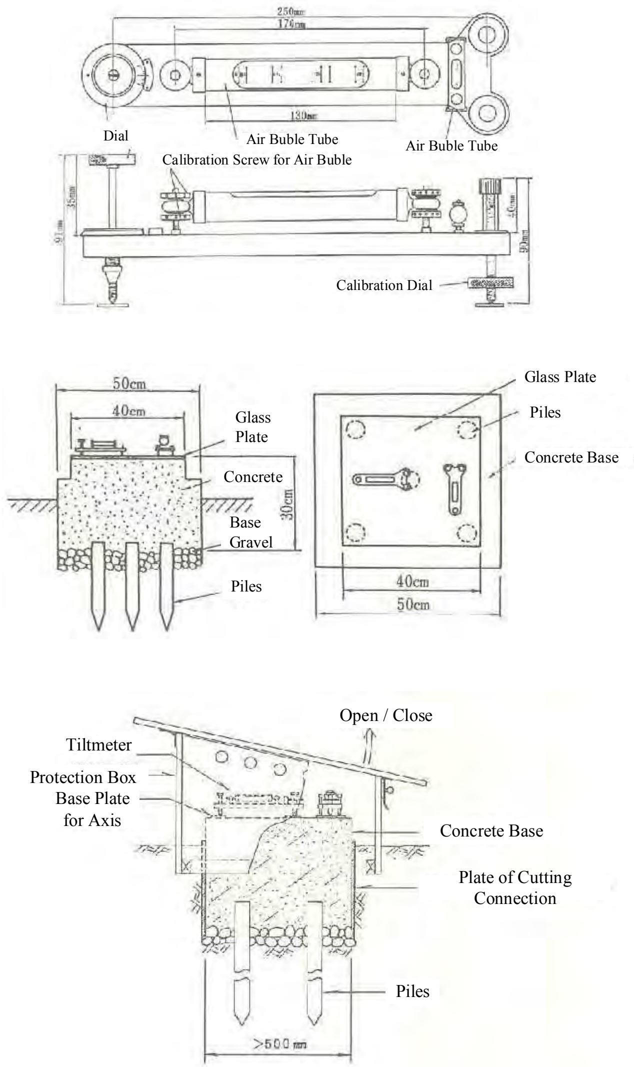


Figure A2-1.7 Typical Installation of Water Tube Tiltmeter

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

Electric type tiltmeter is common for monitor the surface fluctuation. Its installation method is almost same as manual type tiltmeter. The typical electric type tiltmeter is shown in Figure A2-1.8

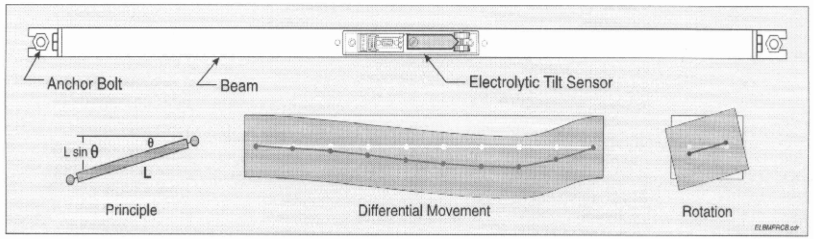


Figure A2-1.8 Electric Type Tilt Meter

A2-1.3 Measurement of the change amount by survey

Fixed-point observation is made on the slope using survey instruments such as a total station, etc. This method enables determination of the change range and change rate.

For marking to fix points, it is essential to secure reflective prisms firmly. Recently, the total station enabling measurement without using dedicated reflective prism has been developed, and attempt is made to apply this station for observation of the slope of steep cliff.

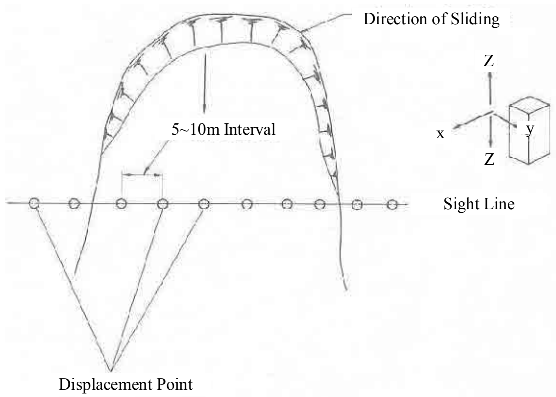


Figure A2-1.9 Sight Survey Outline View

A2-1.6 GPS (Global Positioning System)

This is a radiolocation system using satellite. This method uses 24 satellites arranged along the orbit 20000 km from the earth and can be classified in types according to the ratio utilization method and installation/observation methods of receivers. The static type that is said to be the least in error is used for the landslide area.

Applicability to observation of the slope is limited because of the necessity of over-view, precision machinery, and expensive receiver. The equipment cost is in the rapid downward trend in these days, and the utility value will increase in the future if the accuracy of simplified measurement is enhanced through improvement of the software.

Figure A2-1.10 shows a typical example of the slope displacement monitoring system using GPS. This is called a real-time kinematic type, including multiple GPS receiving points (measurement points) and one GPS receiver (reference point) provided at a point considered immobile. Observation data from these points is collected in a computer via a network, determining and displaying in real time relative three-dimensional coordinates (base line vector) between each measurement point and the reference point.

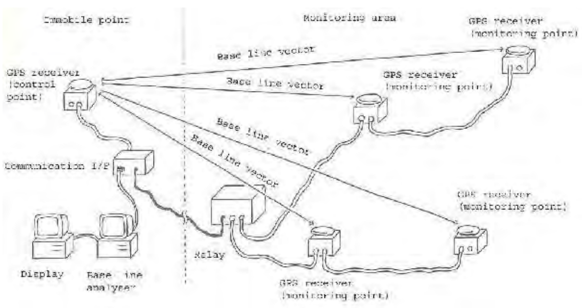


Figure A2-1.10 Typical GPS Displacement Monitoring System

A2-1.5 Strain Gauge

Strain Gauge is commonly applied to the monitoring of structural strain in building construction or civil engineering work. Strain Gauge can be applied to the monitoring of strain on rock or measure structures such as retaining wall.

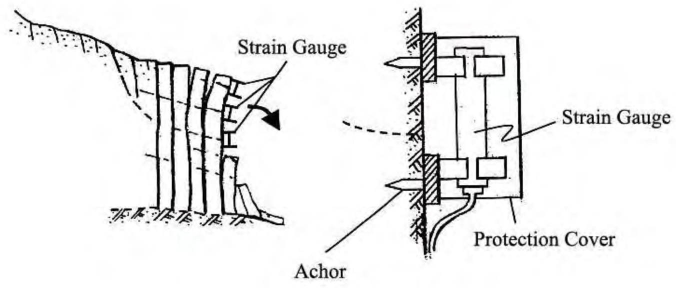


Figure A2-1.11 Example of Strain Gauge Installation on Rock Cliff

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

2.1.6 Crack Gauge

Crack Gauge can monitor the opening speed of crack on rock or concrete structure. Various type of crack gauge are developed as shown in Figures A2-1.12 and A2-1.13. Figure A2-1.12 shows simple measurement of crack. Figure A2-1.13 shows automatic type.

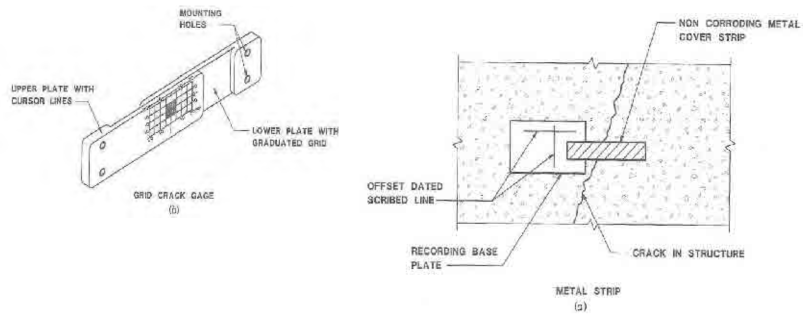


Figure A2-1.12 Manual Crack Gauge (a) Grid Crack Gauge, (b) Metal Strip

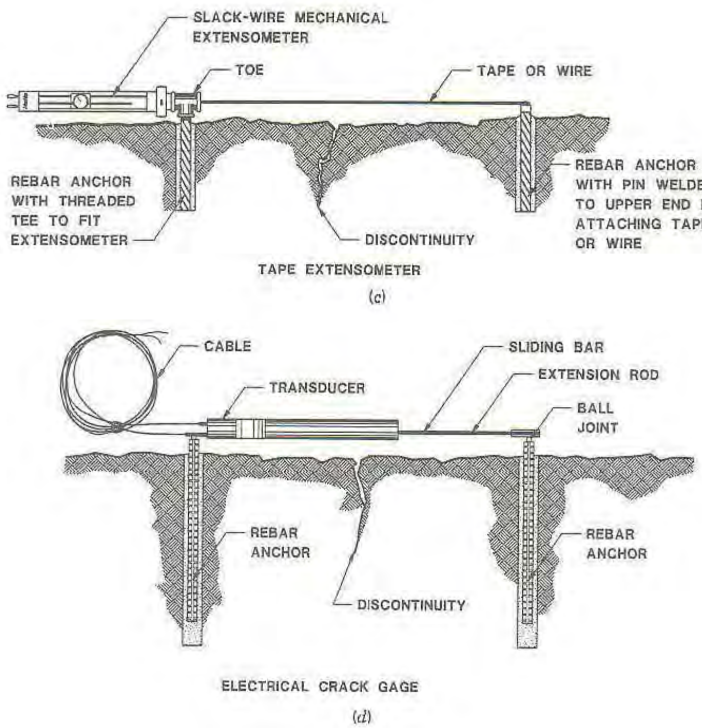


Figure A2-1.13 Automatic Crack Gauge
(a) Tape Extensometer, (d) Electric Crack Gage

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

2.1.7 Rock Fall Detector

Various types of rock fall detector were developed. Three types of detector are common in railway in Japan as shown in Figures A2-1.14 to A2-1.16.

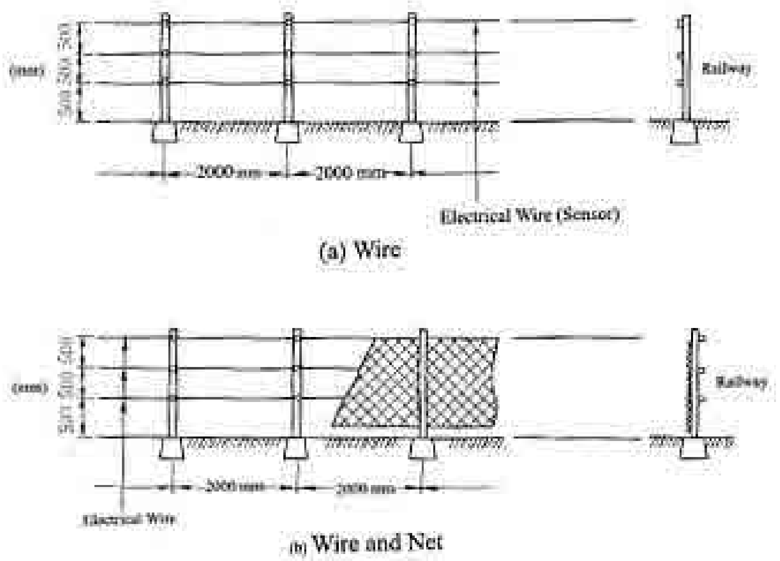


Figure A2-1.14 Example of Rock Fall Detector (Japan Railway)

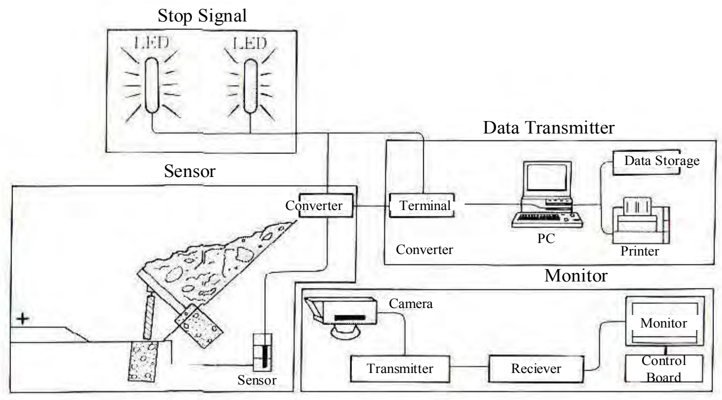


Figure A2-1.15 Example of Slope Collapse Detector (Japan Railway)

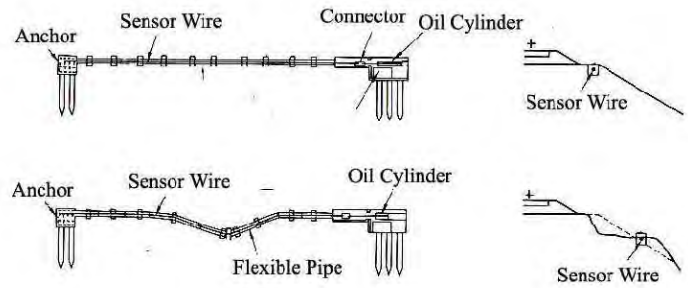


Figure A2-1.16 Example of Embankment Collapse Detector

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

A2-1.8 Fibre-Optic Sensor (New Technology)

In the case of fibre-optic sensor, the sensor itself functions also as a transmission unit, ensuring features appropriate to observation of the road slope, such easy measurement over a wide area, real-time measurement, superior durability, and high resistance against lightening. Initially, the fibre-optic as a sensor utilizes the nature in which the transmission loss occurs when it is bent, mainly detecting deformation of the slope and identification of the location. Recently, studies are active to apply strain measurement technology with fibre-optic using Raman scattered light or Bragg grid to monitoring.

The use as a sensor covering the wire area is mainly for continuous monitoring of slope along the road or area dynamic observation of large landslide. The sensor may also be used for localized monitoring such as measurement in boreholes and countermeasure control. It is expected that the fibre-optic superior in durability enable longer time measurement than existing sensors.

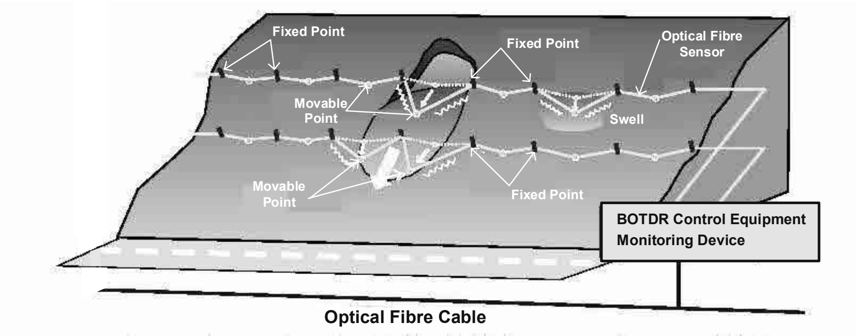


Figure A2-1.17 Model of Optic Fibre Monitoring

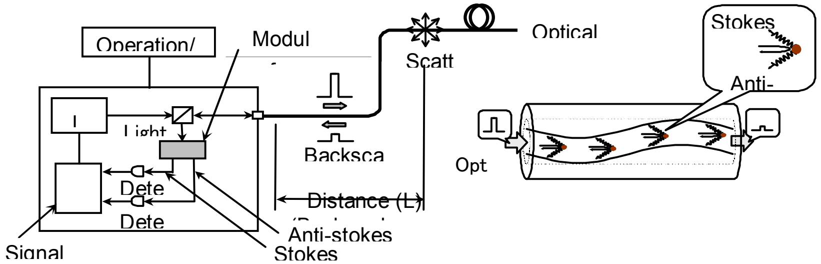


Figure A2-1.18 Principal of Optical Fiver Sensor

A2-2 MEASUREMENTS OF SUBSURFACE FLUCTUATIONS

A2-2.1Inclinometer

(1) Instrument

Two types of borehole inclinometer are available; insertion and stationary types. This section describes the probe inclinometer (insertion type) as a standard monitoring instrument.

In the probe inclinometer, a dedicated guide pipe is inserted and fixed in a borehole and its inclination angle is measured continuously by inserting a probe with built-in sensor in the pipe. In this way, this type of inclinometer is used to determine the slide surface location and the displacement of slide soil mass. As shown in Figure A2-2.2, the cumulative deflection diagram of guide pipe is prepared for the horizontal displacement per 50 cm of the probe length. Then, from the secular change after installation of the guide pipe, the slide surface location, landslide movement and movement velocity are estimated. The probe inclinometer can keep measurement as long as the guide pipe remains normal.

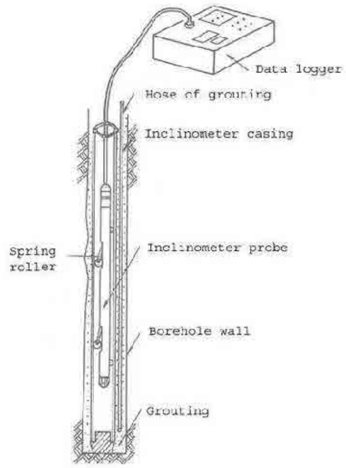
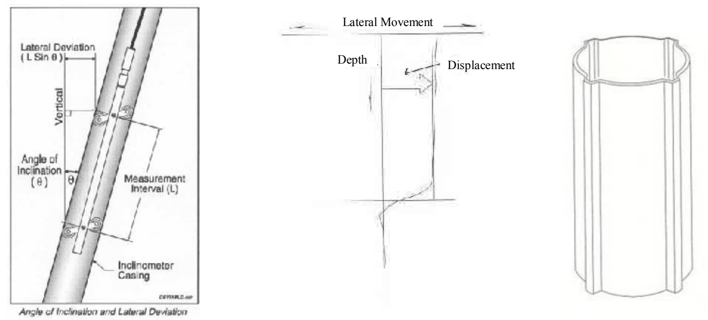


Figure A2-2.1 Graphical Measuring Diagram of the Probe Inclinometer



(a) (b) (c)

Figure A2-2.2 (a) Measurement Principle, (b) Deflection Diagram, and (c) Guide Pipe, of the Probe Inclinometer

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

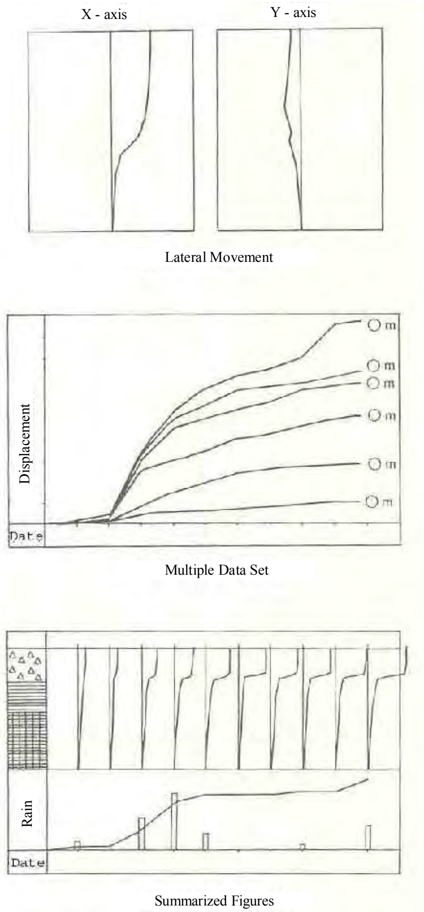


Figure A2-2.3 Typical Analytical Diagram of Measurement Result of the Probe Inclinometer

(2) Installation Method

i) The borehole should penetrate sufficiently to the bed rock below the slide surface.

ii) It is essential to drill the borehole vertically and straight with minimum bend. Setting the guide pipe straight can minimize the measurement error and measurement noise that occur when repeated setting in the same position with high accuracy is difficult.

iii) When the guide pipe is installed, the direction of measurement axis should agree with the movement direction of landslide. No twisting should be applied to the pipe in an attempt to adjust the guide pipe setting direction during grouting. During insertion of the guide pipe, do not force insertion while resisting against the buoyant force. Instead, before grouting, the lower end of guide pipe should be fixed to the bed rock. A plan should work out that allows the pipe to extend upward in the straight condition under the buoyant force of grout.

iv) Grouting of the gap between the borehole and guide pipe thoroughly using cement paste. The grout hose should be inserted, together with the guide pipe, to the lower end of borehole, and grouting should be made from the bottom side so that excavation slurry and slime are discharged to the outside. Insufficient grouting causes unstable guide pipe, resulting in measurement noise.

v) On the ground surface, the guide pipe head should be protected from artificial damage or damage by wild life with a protective tube or underground basin after placement of base concrete.

(3) Measurement, maintenance, and inspection

i) Measurement should be started at least in one week or ten days after grouting, that is, after lowering of grout.

ii) The probe length is more than 50 cm, so that progressive bending of hole may make passage of the probe impossible. While the landslide movement is considerable (exceeding 5 to 10 cm), a dummy probe is first lowered into the hole to prevent jamming.

iii) For measurement, the probe, cable, and logger are connected, with the probe lowered along the guide groove to the hole bottom. Then, the power supply is turned ON and the probe is left as it is for 20 to 30 minutes. This is necessary to prevent temperature drift of measured values from occurring due to temperature change of the probe during measurement because temperature difference exists between above and under the ground surface.

iv) Each of depth marks marked on the cable is set to the zero mark at the hole mouth each time measurement is made. At each mark, the measurement at the deepest point is made in the similar manner. When the current measurement value differs excessively from the previous one, checking should be made to see if there is any water in the connector or if shock has been applied to the probe.

v) The probe is lifted every 50 cm exactly, and measurement is made at each depth by setting the depth mark to the zero mark. When data is obtained in this manner up to the ground surface, the probe direction is inverted and the probe inserted to the hole bottom. When the reading of measurement instrument becomes stable, measurement is made.

vi) The same probe should be used for all measurements. Should the previous probe be changed because of failure, the measurement result should be reviewed carefully. Subsequently, the changed probe should be used continuously.

vii) The sensor in the probe is highly sensitive and susceptible to vibration and shock. During transport, the sensor must be housed in a protective case and handled as if it is made from glass.

viii) The probe and instrument should be checked and serviced two to four times a year to secure the desired accuracy.

ix) The cable connector should always be kept clean and dry. Deteriorated connector packing causes faulty insulation.

x) The cable should be handled with care to prevent bend or twist. Since the cable may be elongated more or less after a long-time use, the length should be verified once a year.

(4) Filing of Data and Judgment

i) From the observation data, the measurement record and calculation, displacement distribution map with X and Y axes for each date, secure displacement map, and contrast diagram should be prepared. The contrast map should include the date, daily rainfall, and groundwater level around the observation point. If necessary, the vector diagram indicating the displacement direction at specific depths should be prepared to determine the landslide movement.

ii) The slide surface position is determined, taking into account the deflection and displacement, from the displacement distribution map.

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

iii) The landslide activity time is determined from secular change of the deflection.

iv) The vector distribution map by deflection direction is checked to see if there is any abnormal twist of the pipe and there is any deviation in the deflection direction by depth.

v) The depth at which the deflection direction changes should not be easily identified as the slide surface. Judgment should be made after overall consideration on the relationship between the boring core, various site investigation results, rainfall, and groundwater level and the movement condition.

A2-2.2 Multipoint Borehole Extensometer

The multipoint extensometer determines the behaviour of landslide soil mass through direct measurement of the wire extension. This wire is fixed at each depth below the ground surface and directed to the aboveground point. This instrument enables determination of the slide surface and the movement on the slide surface.

This instrument is suitable for landslide with large movement. The construction is simple and robust. However, installation of the instrument in the borehole is rather complicated, requiring carefulness and time.

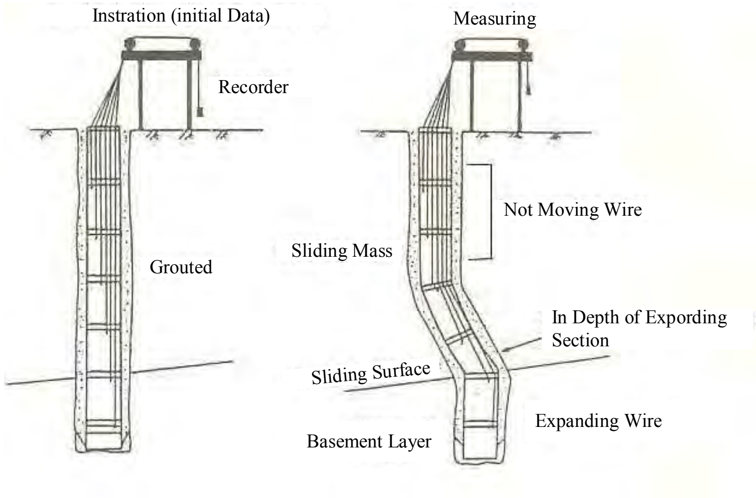


Figure A2-2.4 Concept of Borehole Extensometer

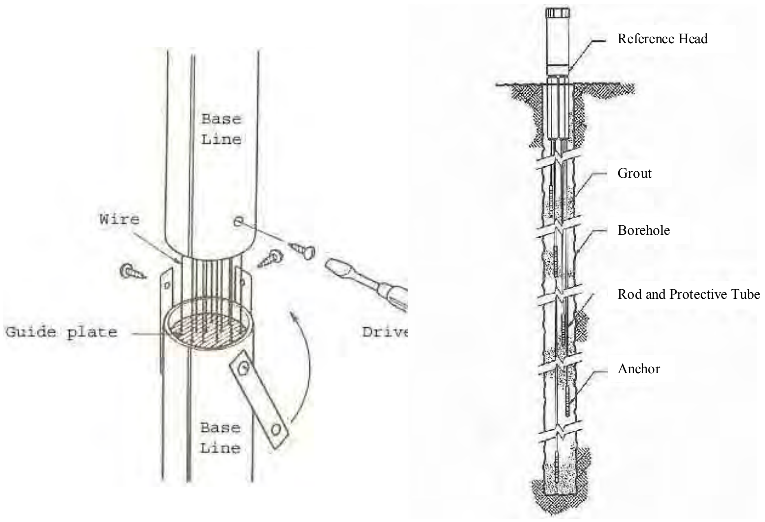


Figure A2-2.5 Detailed Connection Diagram of Multipoint Borehole Extensometer

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

A2-2.3 In-Place Inclinometer

Conventionally, the in-place inclinometer has been used to observe the change condition around the slide surface when the location around the slide surface is roughly confirmed. Recently, a high-performance inexpensive inclinometer has been put into practical application. In certain cases, multiple inclinometers may be arranged in one location for confirmation of the slide surface.

When compared with the insertion type, the stationary type is advantageous in that the difficulty of repeated setting with high accuracy can be eliminated and that it can be combined with automatic/remote measurement and alarm.

Because the cable has to be passed through the guide pipe or PVC pipe, the number of sensors that can be installed per hole is maximum 12 to 16 for the guide pipe type and 24 to 28 for the PVC pipe fixed type. At least one of sensors to be installed should be placed in the bedrock.

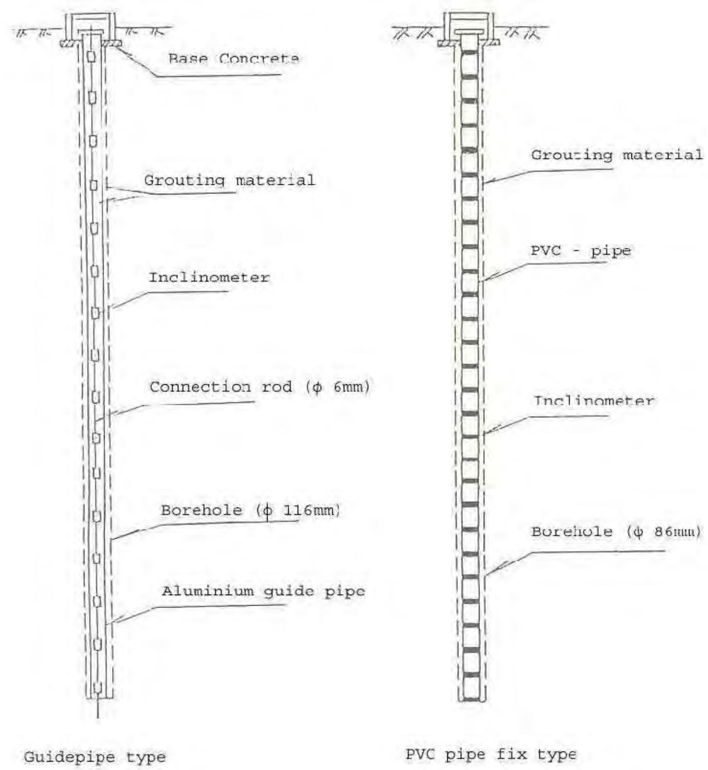


Figure A2-2.6 Typical Installation of the In-Place Inclinometer

A2-2.4 AE (Acoustic Emission) Method

In the case of rock mass slope, strain up to a point of collapse is small and it is difficult for conventional displacement measurement to detect any precursory phenomena. The AE (Acoustic Emission) method is based on the fact that failure is already under way on an extremely small level even before an object develops visible fracture. This method is intended to use the AE wave released when the strain energy is released during extremely small failure for prediction of failure of the rock mass.

Since AE measurement amplifies considerably an extremely weak AE wave generated in the course of progress of failure, due attention should be paid to the types of sensor and measurement instruments and the installation methods.

Figure A2-2.7 shows a typical observation of the rock mass slope according to the AE method. However, there are not much examples of applying this method to monitoring of the stability of rock mass. To promote more positive application in the actual field, there are many subjects to overcome, such as accumulation of field measurement data, review for more rational evaluation methods, etc.

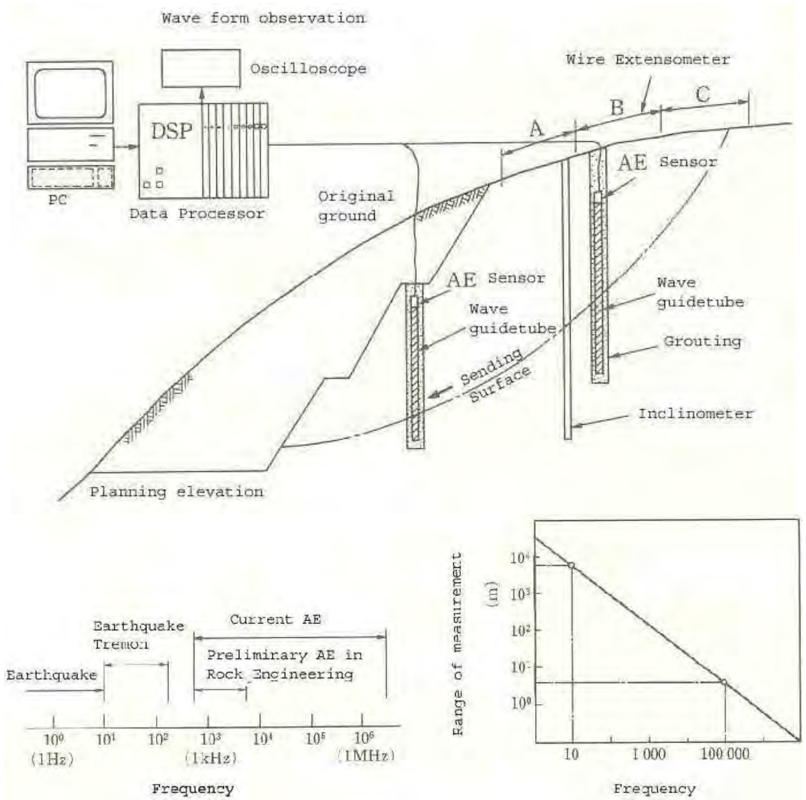


Figure A2-2.7 Outline of AE Measurement on the Slope

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

A2-3 MEASUREMENTS OF GROUNDWATER FLUCTUATIONS (PIEZOMETER AND WATER STANDPIPE)

A2-3.1 Instruments

Groundwater in landslide is in the form of either unconfined groundwater continuing from the ground surface and confined groundwater intervened in impervious layer. Groundwater data necessary for analysis is the pore water pressure on the slide surface.

The geological and hydraulic structure is assumed from the site investigation result, narrowing down to the groundwater zone related to landslide. Then, the water standpipe or piezometer is provided at the position and depth appropriate for confirmation of the groundwater potential distribution in the expected slide surface.

The pore water pressure in the slide surface is the sum of the uplift by groundwater and the excess pore water pressure. In the case of the piezometer, the installation depth is difficult to determine while the slide surface is not yet identified, installation itself is difficult when the slide surface is deeper, and measurement is impossible for certain landslide movement. Because of these reasons, the hydrostatic pressure measured with the water standpipe may often be used instead of the power water pressure.

The water standpipe and piezometer are available in various types depending on the measurement principle and the sensor and recording method. The instrument market is progressive, with development competition in terms of the functionality, long-term reliability, and costs. Therefore, instrument selection should be made according to the objective of investigation and applicability in the field. For example, simple measurement with auger boring is enough for groundwater observation hole near the ground surface. It is essential to have a sense to develop a plan appropriate to the objective. For the model having a water pressure sensor, it is necessary to select the sensor with appropriate measurement range and sensitivity while considering the expected change range of water level.

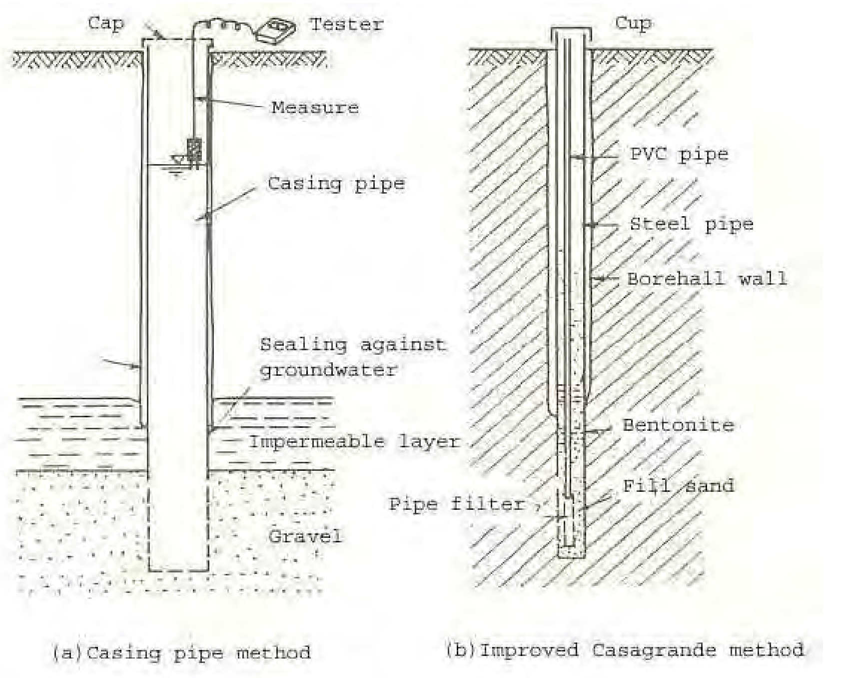


Figure A2-3.1 Typical Piezometer

(a) Water Level Indicator and Filter Tips.
(b)Typical Piezometer Sensors
Figure A2-3.1 Typical Instruments of Groundwater Investigation

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

2.3.2 Installation Method

i) The instrument is installed in a vertical borehole drilled to the slide surface. The depth to the groundwater zone concerned is identified from observation of boring core and other samples and through electric logging.

ii) When the instrument is installed, it is essential to isolate completely groundwater to be measured from other groundwater. The installation method varies more or less depending on whether a standpipe type or a hydraulic type is used. What is common to these types is to perform sealing positively so that the groundwater pressure of the ground concerned can be measured correctly.

iii) The stand pipe type consists of screening of only the hole protection pipe portion facing the groundwater zone portion. No hole is drilled in other portion. The gap between the borehole wall and hole protection pipe is filled with sand for the screening section. At top and bottom ends of the section, sealing is made with bentonite balls or pellet. The section without holes is grouted.

iv) In the case of the hydraulic piezometer, de-aired water is well infiltrated into the porous filter of sensor to purge air from the filter. While the instrument is inserted in the borehole, it must be kept fully immersed in water.

v) After installation, checking should be made to confirm correct installation.

vi) The standpipe, cable, and recording unit on the ground surface should be protected from artificial damage or damage by wild life with a protective tube or underground basin after placement of base concrete.

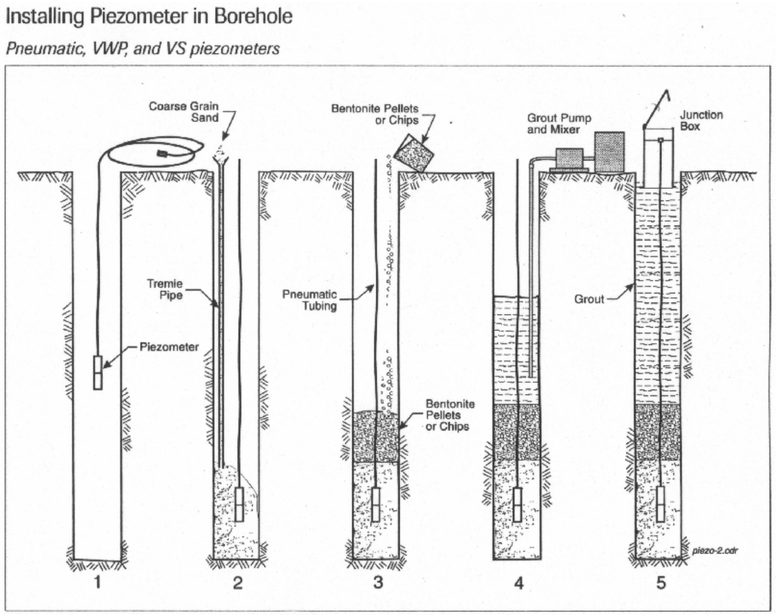


Figure A2-3.2 Piezometer Installation Procedures

2.3.3 Measurement, Maintenance, and Inspection

i) Measurement and maintenance is made according to the method appropriate to each instrument. If the instrument has an electric circuitry, maintenance and inspection to confirm waterproof is necessary. Checking should be made for damage or clogging of the pipe and breakage of the signal cable. Zero adjustment should also be made.

ii) Judgment on whether the measurement result indicates the abnormal value or failure of sensor, such as cutting of the connection pipe due to landslide, malfunction due to electric trouble, mixing of air bubbles at installation, should be made with due consideration of the water level gauge reading and rainfall condition in the neighbourhood.

APPENDIX III-2 INSTRUMENTATION FOR EARLY WARNING

A2-3.4 Filing of Data and Judgment

i) Observation data is filed in the form of the time-groundwater level curve or time-pore water pressure curve.

ii) The water level at start and stop of landslide, maximum and minimum levels, and constant water level are filed and compared with the rainfall and ground change, reviewing the relationship between the water level and landslide.

APPENDIX III-3 RAIN GAUGE MONITORING RESULT
RELATION BETWEEN PRECIPITATION AND DISASTERS

APPENDIX III-3 RAIN GAUGE MONITORING RESULT

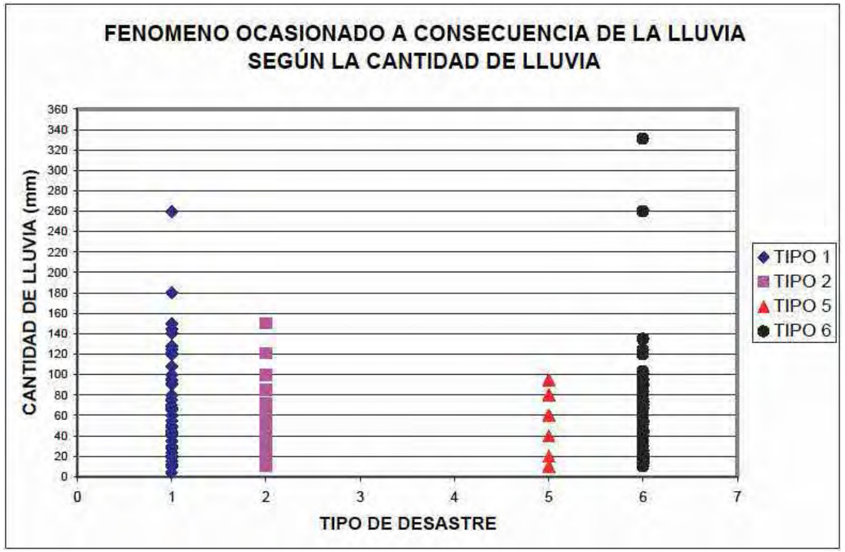


Figure A3-1 Disaster Type - Rain Fall Accumulation

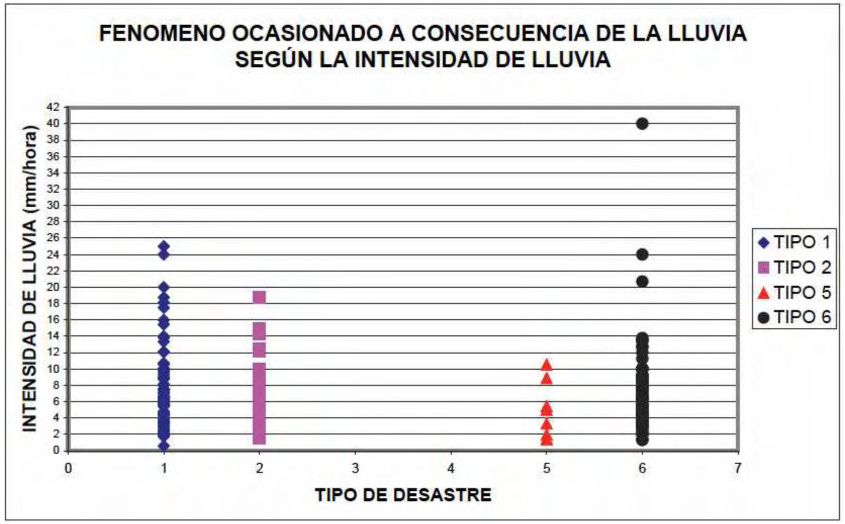


Figure A3-2 Disaster Type – Rain Fall Intensity

Left figures show relation between disasters and rain falls which were obtained by the Micro-empresas using simple rain gauges. Total 19 rain gauges along route 3 from Caranavei to Quiquibey were monitored from August 2006 to April 2007. The graphs use result of the nearest rain gauges to each disaster. The disaster types are based on the figure shown on page I-2 in Guide I.

The upper figure shows the relation between disaster type and rain fall accumulation and the lower figure shows the relation between disaster type and rain fall intensity.

Both figures show that disasters occur in less rain. The reason may be;

1. All types of disasters even small phenomena were rerecorded, becuase the disasters have been recorded by the Micro-empresas who are not expert of road disasters,.
2. In Bolivia, occurrence of disasters may not be affected by accumulation of rain fall or rain fall intensity, but by period of rain falls.

The rain fall monitoring by the Micro-empresas using simple rain gauge shall be continue, and the data shall be accumulated for future analysis.

(June 2007)

ROAD DISASTER PREVENTION MANAGEMENT MANUAL

GUIDE IV

EMERGENCY RESPONSE

ABC

JICA

CONTENTS

GUIDE IV EMERGENCY RESPONSE

1 INFORMATION TRANSMISSION AND ORGANIZATION ON EMERGENCY

2 EMERGENCY INSPECTION

3 EMERGENCY MEASURES

4 TEMPORARY RESTORATION

5 PUBLIC NOTICE

6 RECORD OF DISASTERS

CONTENTS

OUTLINE

This is a guide for emergency responses in case of road disasters. When the disaster occurs, mostly first information could come to the police, and the police inform to ABC regional office.
The ABC regional office shall set up the emergency organization headed by the chief of the ABC regional office (the Jefe Regional), and send the supervisor to collect the detailed information as soon as possible. If the supervisor could not reach the spot immediately, the supervisor shall solicit the micro-empresa for their observation and report to the Supervisor.
All the information shall be concentrated to the Jefe Regional, and the Jefe Regional shall take the responsibility of all the actions done by ABC, the supervisor and the micro-empresa.
The purpose of the emergency measure and the temporary restoration is to keep the safe traffic flow as soon as possible. However, if it is difficult to keep the safety of the road, the traffic shall be controlled.

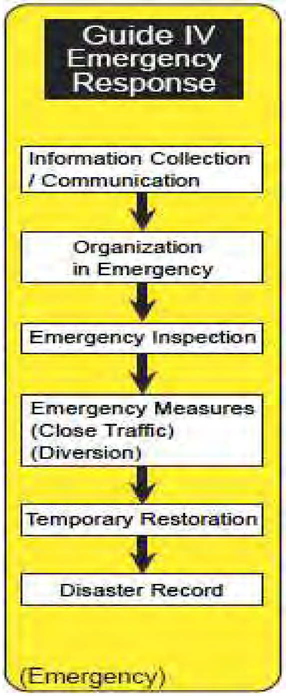


Figure 0.1 Contents of Emergency Response

1 INFORMATION TRANSMISSION AND ORGANIZATION ON EMERGENCY

When a disaster occurs on the highway, the information transmission is activated as shown in Figure 1.1.

Disaster Information Collection

The person who would come up against or find a disaster can be drivers, inhabits of the Micro-empresas. All the information of disasters collected by drivers or inhabitants is concentrated to the police through call 110 or through a tall gate. And all the information of disasters collected by a Micro-empresa shall be concentrated to the ABC regional office through the Supervisor.

Role of ABC Regional Office in Information Transmission

Usually, ABC regional offices receive the information of disaster from the police or the Supervisor. Once an ABC regional office receives the information, it shall set up the emergency organization headed by a general manger as soon as receiving the information of disaster.
All of the information about road disasters shall be centralized to the general manger of the ABS regional office. In house communication of ABC shall be in accordance with the emergency organization set above. An ABC staff in the regional office who receives the first information shall call the Supervisor of the section to the disaster as well as the general manager.
The general manager shall report to the department of highway conservation of ABC Head office successively.
In disaster season (rain season), the emergency organization shall have to be set for the disaster.

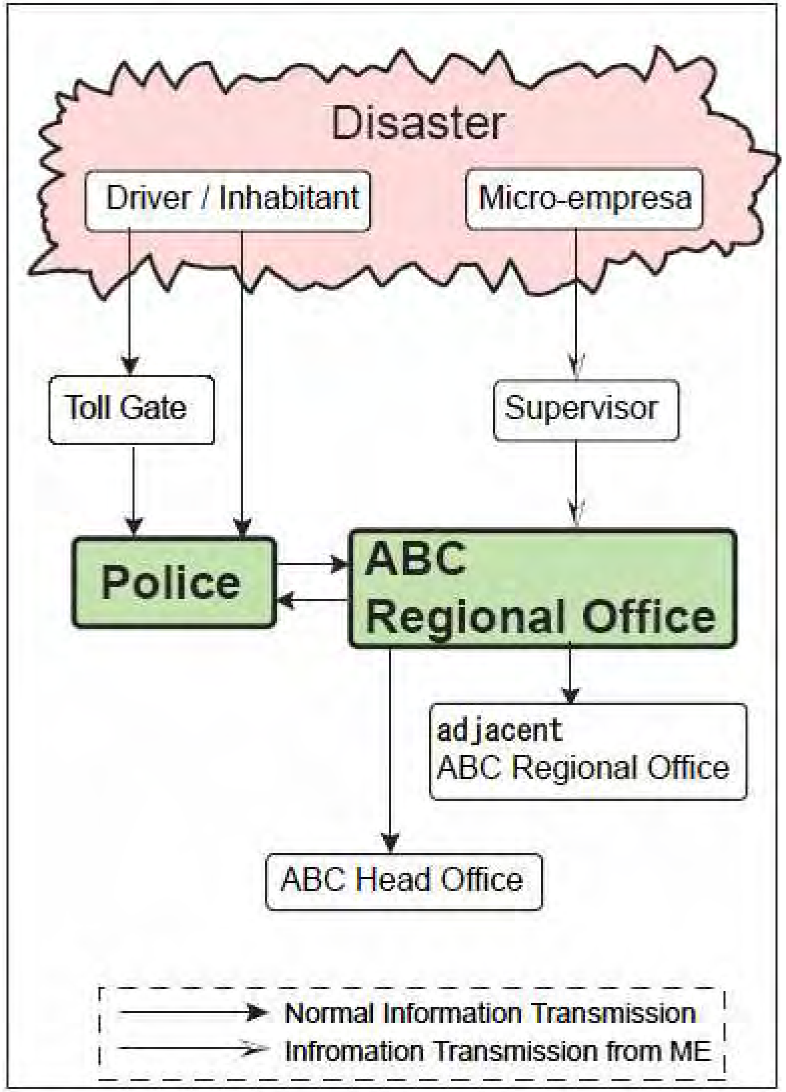


Figure 1.1 Flow of Disaster Information

1 INFORMATION TRANSMISSION AND ORGANIZATION ON EMERGENCY

Jefe Regional (Chief of Regional Office)

directive, order, control the team

(instruction) ↓ ↑ (report)

Ingeniero de Seguimiento (Follow-up Engineer)

inspect the site of disaster, investigation, control the supervisor

(instruction) ↓ ↑ (report)

Supervisor

inspect the site of disaster, investigation, control the micro-empresas

(instruction) ↓ ↑ (report)

Micro-empresa

support the traffic control work, small countermeasure works

The general manager who received the information of a disaster in his jurisdiction shall appoint a follow-up engineer to the engineer in charge of the disaster.
In case the general manager of the regional office is absence, he shall appoint a follow-up engineer to the person in charge of the disaster in advance, and the appointed Follow-up engineer shall act as the general manger proxy.
In emergency, ABC head office receives report from the regional office.

2 EMERGENCY INSPECTION

When the Regional Office received the first information of disaster should solicits the Supervisor in charge of the section for inspection work at the site as soon as possible.
If the Supervisor takes longer time to reach the site, the Supervisor shall solicit the Micro-empresa in the section for observation of the site.
The micro-empresa shall report the site condition to the Supervisor in charge.
The Supervisor shall report the site's conditions to the Follow-up engineer in charge.
The items of report shall be report are as follows.

<u>Micro-empresa</u>

a. Existence of the disaster
b. Location of the disaster
c. State of the road surface
(covered with debris?, collapse of the road? cave-in in the road?, crack on the road or surround?)
d. Possibility of passing
(overall suspension?, one side closed?, negligible?)
e. Existence of vehicles involved or victims
f. State of surrounding
(continuation of small collapse or small rock fall?, progression of cave-in in road?, progression of widening of cracks?)

<u>Supervisor</u>

a. Existence of the disaster
b. Time of Occurrence of Disaster (by hearing)
c. Location of the disaster
d. State of the road surface
(covered with debris?, collapse of the road? cave-in in the road?, crack on the road or surround?)
e. Possibility of passing
(overall suspension?, one side closed?, negligible?)
f. Existence of vehicles involved or victims
g. Existence of facilities involved
h. Type of disaster
i. Necessity of traffic control
j. Estimation of traffic control period
(less than one day?, 1day-1week?, over one week?, over one month?)
k. State of surrounding
(continuation of small collapse or small rock fall?, progression of cave-in in road?, progression of widening of cracks?)
l. Type of countermeasure works estimated

2 EMERGENCY INSPECTION

When the following circumstances are found, overall traffic or one side traffic shall be closed.

Slope above road surface
- Collapse on slope surface
- Blockade by debris collapsed reaches to the lane or the road shoulder
- Continuation of small collapse or rock fall

Slope below road surface
- Embankment failure or road subsidence reaches to only road shoulder, one side traffic shall be closed.
- Embankment failure or road subsidence reaches to cruising lanes, close the road.
- Subsidence of road surface is even and shape of embankment is still kept, the traffic speed shall be controlled.
- Embankment behind structures such as retaining wall subsides, open the road with temporary work such as steal cover after close the road short while.
- The road has been disappear, close the road

3 EMERGENCY MEASURES

The emergency measures means light works which the Supervisors and the Micro-empresas at the disaster-striken area. The emergency measures usually include traffic control and countermeasure works.
The works that are realized in these instances limit themselves to being minor works for example:

- Pic up all small falling rocks
- Clean up road surface
- Relaying of signalling

Traffic control shall be executed in order to keep vehicles and pedestrians safety. If the road is in danger of being swept away or not capable of being used by the disaster, the supervisor shall take measure of close the road. In order to avoid accident furthermore, the micro-empresa can close the road as the emergency measure.

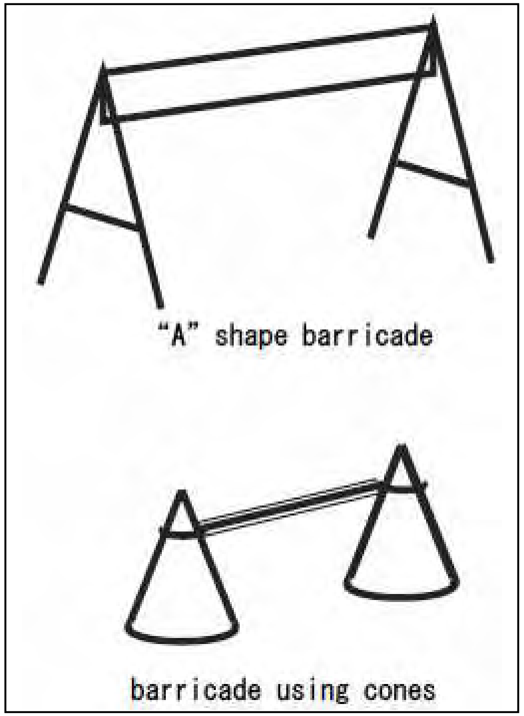


Figure 3.1 Example of Barricades

Example of ways of traffic control

a. traffic control with safety devices
   close with "A" shape barricades and ropes
   close with safety cones
   close with sign board

b. traffic control without safety devices
   use material which attract drivers' attention
   put the poles or red flags at danger points

4 TEMPORARY RESTORATION

When the road is suffered from disaster, temporary restoration work shall be executed in order to keep the faculty of road.
The temporary restoration shall be executed efficiently with the analysis of information which collected in the emergency inspection.
The actions for the temporary restoration is classified in to three levels depend on the magnitude of disaster, small scale, medium scale and large scale.

In this point the ABC should already be provided with a plan or design to repair the disaster, in Bolivia the disasters mostly happen in regions of mountain range and so, if in some case it considers to re-locate the route will be very difficult since the topography does not allow it to us and the only procedure will be the close of the highway until the works of restoration have been concluded or the works of construction finished if it was a disasters of big magnitude.

Depending on the size of disaster the follow-up engineer will be related to the disaster (taking decisions or possible solutions), in case the disaster is of big magnitude the ABC and the Regional Office will have to take charge realizing the preventive measurements, construction or contract of some consulting company that takes charge of the design and construction of the works of restoration.

Small Scale Disaster

When the magnitude of the disaster is equivalent to few hours to one day closure of the road, the following procedure must execute to rehabilitate the affected area immediately.

1) The Supervisor will solicit the regional office for the authorization to mobilization of the necessary workers and machinery for the rehabilitation of the affected area.
2) The supervisor will execute the design of emergency / temporary works against the disaster.
3) The Supervisor will solicit the design approbation of the rehabilitation works to the regional office and risk management unit to be executed by the contractor immediately.
4) The Supervisor will organize the execution of the emergency works according to the magnitude of disaster with the maintenance company.
5) The contractor will execute all the necessary emergency works for the rehabilitation of the area, such as removal of collapse soil, debris or falling rocks, and cleaning and rehabilitation of road surface and drainages, construction of temporary countermeasures, based on the approved design.
6) The Supervisor and the contractor must stay on the disaster site all the necessary time during the emergency works are going on.
7) Once the rehabilitation works have been finished and the disaster state has been deactivated, the Supervisor will communicate to the toll controls, road police, local authorities and users that the emergency state is over and the road is open again.

4 TEMPORARY RESTORATION

Medium Scale Disaster

When the disaster produce the temporal closing of the road by a period of over one day to one month, the ABC risk management unit must realize and approve the work design of the rehabilitation for the opening of the road immediately by the Supervisor.

1) The Supervisor will identify the alternative road and communicate the opening of alternatives road to the ABC Regional office while the emergency is going on.
2) The Supervisor will solicit the authorization for the mobilization of workers and machinery to the emergency road section in coordination with the contractor company in charge of the road section maintenance.
3) The Supervisor in coordination with the maintenance fiscal will design the emergency rehabilitation works and will solicit its approval to the Regional Office and ABC Risk Management Unit.
4) The ABC Risk Management Unit shall approve the design of the rehabilitation works and shall manage the necessary resources for the execution of the work and coordination with the Regional Office and the ABC's GCV.
5) The Supervisor in coordination with the contractor in charge of maintenance will be the responsible of the execution of the rehabilitation works immediately.
6) Once the rehabilitation works have been finished and the disaster state has been deactivated, the Supervisor will communicate to the toll controls, road police, local authorities and users that the emergency state is over and the road is open again.

Large Scale Disaster

When the disasters produce the temporal closing of the road by a period of over one month, due to failure of road sections or the failure of a major structure like a bridge, the Supervisor will identify and communicate the opening of alternatives road for the transit of vehicles while the emergency period is going on.

1) The Supervisor will identify the alternative road and communicate the opening of alternatives road to the ABC Regional office while the emergency is going on.
2) The Supervisor will maintain and supervise the alternative road while the emergency period is going on.
3) The Supervisor in coordination with the maintenance Fiscal and Regional Chief will communicate to the Risk Management Unit and ABC's GCV, the location and magnitude of the disaster.
4) The Risk Management Unit, and the ABC's GCV, will coordinate with the Department Prefecture and other emergency institutions the necessary measures and the resources management for the rehabilitation of the road section.
5) The ABC Risk Management Unit will design and will approve the rehabilitation works, or shall contract one Consultant specialist for the design of the work.
6) The ABC in coordination with the Regional Office, shall contract one specialist company, or the company in charge of the maintenance for the execution of the rehabilitation works in the affected route.
7) Once the rehabilitation works have been finished and the disaster state has been deactivated, the Supervisor will communicate to the toll controls, road police, local authorities and users that the emergency state is over and the road is open again.

5 PUBLIC NOTICE

The traffic control resulting from disasters blocks physical distribution network, and causes a loss of economy in the country.
The information of the traffic control shall be published in order to prevent many vehicles involving in the traffic control.
Most realistic and effective method* of publication of traffic control is to utilize the tollgates which spread on the highways in the country.
A sign board which contains same information across the country is post at each tollgate, because the movements of vehicles are rapid.
Because the information shall be spread promptly after the incident, the new system which transmits the information to all tollgates in the country shall be established. Figure IV-5.1 shows flow of information communication from ABC regional offices to tollgates. An important matter in the figure is existence of operation center which collect all information from ABC regional offices and send information to all tollgates.
Figure IV-5.2 shows example of the sign board posted at tollgates.

*

There various method of publishing traffic control information. Utilizing the mass media such as radio and television is one of the way, but information may broadcast epherally and many drivers could miss the information.
The another way to publish the information is to send information to users parties such as tracker association, bus company association. But it is not the best way, because limited drivers could access to the information and many drivers could not.

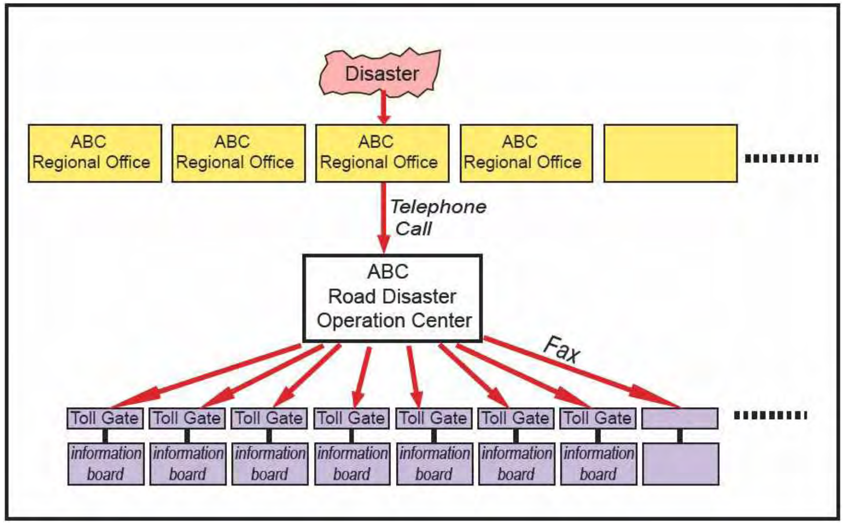


Figure IV-5.1 Flow of Information Communication to Tollgates

NATIONAL HIGHWAYS INFORMATION BOARD

UPDATED AT **10:30 / 17 Feburuary 2007**

Route	Section from	Section to	Cause	Period from date	from time	to date	to time		Condition
4	Quimone	Paso	flood	13 / 02	15:30	20 / 02		estimate	closed to all vehicles
23	Puyuyo	Vacas	landslide	14 / 02	7:00	05 / 03		estimate	closed to all vehicles
7	Pojo	Comarapa	landslide	14 / 02	13:30	unknown			closed to all vehicles
4	Guanuma	Comercocha	landslide	15 / 02	23:15	17 / 02	0:00	estimate	closed to over 4t trucks
16	Alto Madidi	Guarayos	maintenance works	17 / 02	7:00	17 / 02	18:00		closed to all vehicles
3	Quiquibey	Yucumo	landslide	17 / 02	9:30	unknown			closed to all vehicles

Figure IV-5.2 Example of Sign Board which Announces Traffic Control Sections in the Country

6 RECORD OF DISASTERS

After all of this process and once the disaster have been handled there will be used a Disaster Record Form in which there will be explained the Location of the disaster, hour, date, magnitude, road condition and damage etc.
The recorded forms shall be registered in the ABC regional office in charge and in ABC head office, and practically used for analysis of disasters and plan of disaster prevention measures in accordance with Manual of based on another manual, Manual of Major Book of Disaster (Libro Mayor de Desastre).

APPENDIX IV-1 DISASTER RECORD FORM

This form is not prepared in this manual.
The detailed of the form is shown in Manual of Major Book of Disaster (Libro Mayor de Desastre).

APPENDIX IV-1 DISASTER RECORD FORM

HOJA DE INSPECCIÓN DE DESASTRES *ABC / JICA*

Ruta Nº :	Sección :	Inspeccionado por :	
Progresivas :	*km* - *km*	Fecha de Inspección :	*(dd/mm/aa)*
Cordenadas : *lati.*	*long.*	Revisado por :	
Lado del Camino :	Derecho ☐ Izquierdo ☐	Fecha de Revisión :	*(dd/mm/aa)*

Condición del Desastre

SOCIAL	Ocurrencia (dd/mm/aa)	*Hora:*
	Reporte (dd/mm/aa)	*Hora:*
	Reportado por:	*Chofer* ☐ *Residentes* ☐ *ME* ☐ *Supervisor* ☐ *Policía* ☐ *Otros* ☐ *No identificado* ☐ *Otros :*
	Vehículos Involucrados	*Número:* *Tipo:* *Daños causados:*
	Personas involucradas :	*Número:* *Condición:*
TIPO DE DESASTRE	Sección Típica :	0 1 ☐ 0 2 ☐ 0 3 ☐ 0 4 ☐
	Tipo de Desastre :	*Tipo 1* ☐ *Tipo 2* ☐ *Tipo 3* ☐ *Tipo 4* ☐ *Tipo 5* ☐ *Tipo 6* ☐ *Otros* ☐ *Otros :*
	Repetitivo en esa ubicación :	Repetitivo ☐ Nuevo ☐
	Dimensión del Desastre :	
CLIMA	Cuando el desastre ocurre :	*Lluvia* ☐ Lluvia Fuerte ☐ *Nublado* ☐ *Bueno* ☐ *No claro* ☐
	Estado del clima 48 horas antes del desastre:	*Lluvia* ☐ Lluvia Fuerte ☐ *Nublado* ☐ *Bueno* ☐ *No claro* ☐
	Condición Meteorológica:	*Húmeda* ☐ *Seca* ☐
CAUSA	Causa del Desastre :	*Lluvia* ☐ *Terremoto* ☐ *Actividad Humana* ☐ *Erosión por Río* ☐ *No claro* ☐ *Otros* ☐ *Otros:*

Condición de la Carretera

SUPERFICIE DE LA CARRETERA	Tipo de Pavimento :	*Asfalto* ☐ *Concreto* ☐ Empedrado ☐ Ripio ☐ Tierra ☐ Otros ☐ *Otros:*
DRENAJE EXISTENTE	Drenajes :	*Longitudinal* ☐ *Tipo cascada* ☐ *Transversal* ☐ *Otros* ☐ *Otros:*
	Condiciones :	*Buena* ☐ *Necesita limpieza* ☐ *Necesita reparación* ☐ *Otros* ☐ *Otros:*
MEDIDAS DE PREVENCIÓN EXISTENTES	Medidas :	*Gaviones* ☐ *Muro de Concreto* ☐ *Pernos de Roca* ☐ *Clavos de Roca* ☐ *Enmallado* ☐ *Dique* ☐ *Otros* ☐ *Otros:*
	Cantidad :	
TALUD	Tipo de Talud :	*Natural* ☐ *Corte* ☐ *Corte + Natural* ☐ *Quebrada* ☐ *Relleno* ☐
	Cobertura del Talud	*Descubierto* ☐ *Pasto* ☐ *Arbustos* ☐ *Arboles* ☐ *Mortero lanzado* ☐ *Otros* ☐ *Otros:*
	Material del Talud:	*Roca dura* ☐ *Roca blanda* ☐ *Roca meteorizada* ☐ *Sedimento* ☐ *Coluvios* ☐ *Otros* ☐ *Otros:*

Propuesta

Medidas Preventivas Propuestas | Periodo de Desviación Temporal :

Item	Cantidad	Unidad	Precio Unitario	Costo (Bs.)
	Costo Total (Bs.)			

Comentarios:

ACTIVIDADES ACTUALES

Periodo de Perturbación	Intransitabilidad: desde / / hasta / / Fecha de reapertura: / /
Medidas Preventivas	

HOJA INSPECCION DE DESASTRES (FOTOGRAFIA) *ABC / JICA*

Ruta Nº :	Progresivas:	Lado del Camino :	Fecha:

Fotografías