APPENDIX - A

A-1: A Guideline for Slope Inspection for Maintenance of Roadside Slope in the Islamic Republic of Pakistan

A GUIDE

OF

SLOPE INSPECTION

FOR

MAINTENANCE OF ROADSIDE SLOPE

IN

THE ISLAMIC REPUBLIC OF PAKISTAN



January 2008

TECHNICAL ASSISTANCE FOR RECONSTRUCTION OF

BRIDGES DAMAGED BY OCTOBER 8 EARTHQUAKES ON

THE JHELUM VALLY ROAD

PAKISTAN TRANSPORT PLAN STUDY IN THE ISLAMIC REPUBLIC OF PAKISTAN

PREFACE

An earthquake measuring 7.6 on the Richter scale struck the northern areas of Pakistan and India on October 8, 2005. Numerous landslides were activated by the earthquake and pose considerable hazards to people and property. Risk reduction of landslides is an urgent need for the reconstruction of severely damaged areas.

In Pakistan, road maintenance works to safeguard against landslides have been conducted on a routine or a periodic basis and the knowledge of slope protection techniques has been accumulated accordingly. However, there is no manual or standards for slope inspections. Insufficient measure against a landslide due to the lack of necessary field data causes frequent landslides, which consequently impose financial strain in road maintenance.

For risk reduction of landslides, it is therefore essential to prepare the guide of slope inspection and to provide an assistance of capacity building of slope inspection for the staff in charge of road maintenance works.

Based on the perspective, this Guide has been prepared for the purpose of the risk reduction of landslides through the development of the slope inspection for road maintenance. In view of circumstances in a lack of specialized engineers for slope stability, this Guide emphasizes the dissemination of an essential knowledge to the staff in charge of the road maintenance in Pakistan. Furthermore, the Guide also covers emergency measures in a response to the urgent need of landslide risk reduction, since an appropriate and timely measure can prevent recurring landslides and help in the rehabilitation procedure.

This Guide is comprised of two chapters, the first of which gives the basic concept of the slope protection and the scope of application of this Guide and the second chapter provides many lessons from the experiences of landslides.

With respect to road maintenance, many of its concepts introduced in this Guide owes to “Road Association of Japan (1999), Highway Earthworks Series: Manual for Slope Protection”, and many materials of the experiences of landslides are referred to “Slope Inspection Guide Series I~III” published by Japan Highway Public Corporation (JH) in 1983, 1986 and 1989.

In addition to the references above, geological data and photographs of landslides and some mitigation measures against landslide on the existing roadside slope were obtained through the site inspections in collaboration with NHA and GSP (Geological Survey of Pakistan) from June 2006 to Aug 2007 covering two wet seasons after the earthquake.

In general, “Landslide” includes various types of slope failures, and also has a regional variety in geological condition. Moreover, it should be recognized that physical and mechanical characteristics of the article slopes should be worsen slowly over time. The lessons mentioned in this Guide might include some exceptional cases due to these uncertainties.

Therefore, we hope this Guide will prove appropriable through actual slope inspections and new knowledge of slope stability will be accumulated in the due course of new findings.

JICA Study Team

THE GUIDE
OF
SLOPE INSPECTION
FOR
MAINTENANCE OF ROADSIDE SLOPE
IN
THE ISLAMIC REPUBLIC OF PAKISTAN

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Abbreviations

AJK	Azad Jammu and Kashmir
NWFP	North West Frontier Province
NHA	National Highway Authority
GSP	Geological Survey of Pakistan
JICA	Japan International Co-operation Agency
JH	Japan Highway Public Corporation

Glossary

Alluvial fan:	Fan-shaped unconsolidated deposits of water transported materials
Countermeasure:	Measure applied to control the failure
Debris flow:	Type of landslide, rapid flow of boulder, gravel, sand, silt, and clay mixed with a large quantity of water that is mainly generated by landslide and heavy rainfall
Embankment failure:	Type of landslide which occurs as slump or slide of slope, settlement of road etc.
Erosion:	Displacement or denudation of soil by rain drops, seepage etc.
Hazard:	The probability that a particular danger occurs in a particular area within a given period of time.
Inspection:	Official examination
Landslide:	Geological phenomena of slope deformation and movement including debris flow, landslide (landcreep), rock fall and rock mass failure (the definition in this Guide)
Landslide (landcreep):	Type of landslide, mass - creeping of highly weathered rocks, debris and soil along a rupture surface (the definition in this Guide)
Mitigation:	Making less severe
Regular inspection:	Inspection carried out regularly, at least once a month
Risk:	The probability that a potential hazard will be realized and the probability of harm itself
Roadside slope:	All type of roadside slope including natural slope, cut slope and embankment etc.
Rock fall:	Type of landslide, free fall or rolling down of stones/rocks individually from a steep slope or cliff
Stability:	Fixing firmly, not easily shaken or destroyed
Weathering:	Decomposition or softening of rocks

Chapter 1 Introduction

1.1 Maintenance of Roadside Slope

1.1.1 Background of Maintenance of Roadside Slope

Numerous landslides, which mostly became active after the October 8th 2005 Earthquake, have posed considerable hazards to the people and their property. The roads damaged by the earthquake are always suffered to landslides hazards, which cause to harm the steady rehabilitation. Maintenance of roadside slope is therefore necessary for the risk reduction of landslides in these severely damaged areas.

1.1.2 Maintenance of Roadside Slope

Maintenance of roadside slope is divided into two processes “Slope inspection” and “Implementation of Rehabilitation Works”.

Slope Inspection

Slope inspection is conducted for the purpose of the obtaining the necessary data to evaluate the slope stability, and to conduct effectual countermeasures.

There are four type slope inspections “General Slope Inspection”, “Regular Slope Inspection”, “Periodic Slope Inspection” and “Emergency Slope Inspection” as described in Section 1.2.

“Slope Inspection Sheets” are created based on the results of General Slope Inspection (A sample of Slope Inspection Sheets is shown in Figure 2.4).

Implementation of Rehabilitation Works

Based on the slope inspection, appropriate rehabilitation works are conducted. Records of “Emergency Measures”, “Comprehensive Study for Countermeasures”, and “Implementation of Rehabilitation Works” are used to update “Slope Inspection Sheets”.

Basic flow of Maintenance of Roadside Slope is shown in Figure 1.1.

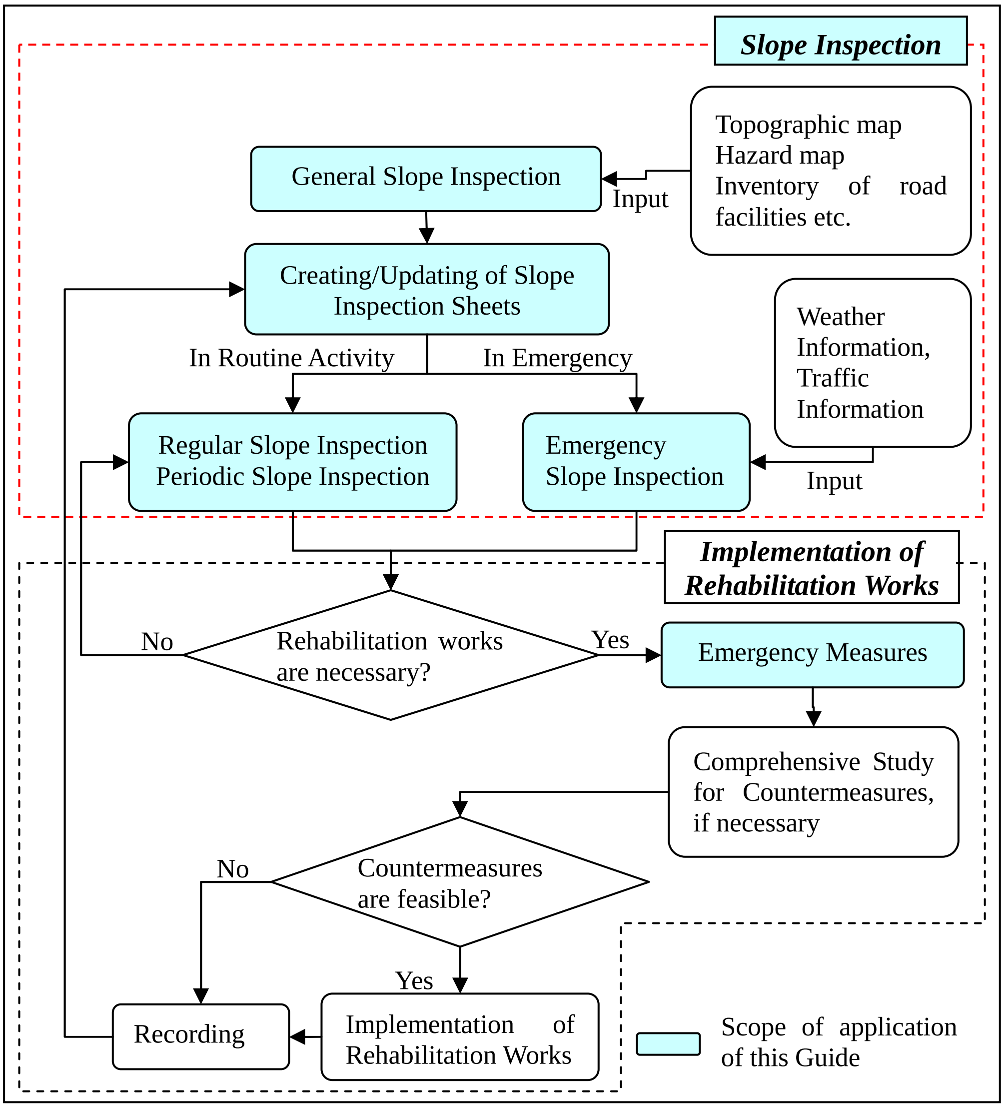


Figure 1.1 A Work Flow for Maintenance of Roadside Slope (Reference: Japan Road Association (1999), partially modified by JICA Study Team)

1.2 Slope Inspection

1.2.1 Basic Concept of Slope Inspection

Risk reduction of landslides can be effected through effectual countermeasures based on slope inspections. Since slope stability is subject to many factors such as, topography, geological structure, soil/rock type, surface and ground water conditions, and effectiveness of protection work, the accuracy of the results of slope inspection shall affect the outcome of the rehabilitation works to be applied.

Furthermore, even an appropriate designed and constructed slope must deteriorate through weathering and erosion, and it is therefore hard to understand a long-term perspective about slope stability at the design stage and even at construction stage. Slope inspection also plays an indispensable follow-up maintenance to keep a proper function of the traffic and to enhance its safety.

1.2.2 Type of Slope Inspection

(1) General Slope Inspection

General Slope Inspection is recommended to be conducted at five to ten years interval. The objectives of General Slope Inspection are to identification and screening of landslides. Results of the slope inspection are summarized in “Slope Inspection Sheets”, which is the basic data to be used in the following slope inspections.

Prior to the slope inspection, related data such as topographic maps, geological maps, hazard maps, an inventory of the facilities of road system should be collected, or should be prepared, if necessary.

(2) Regular Slope Inspection

Regular Slope Inspection is recommended to be carried out at least once a month, although its frequency may be adjusted based on slope condition, traffic volume and other engineering or social conditions.

The objective of Regular Slope Inspection is to check the slope condition regularly, and to take an immediate and appropriate action to reduce landslide risks.

(3) Periodic Slope Inspection

More than twice a year, before and after wet season is recommendable.

The objective of Periodical Slope Inspection is to check the slope condition in detail before wet season and to assess the damage and deterioration of road structures after wet season, and to take an immediate and appropriate action to reduce landslide risks.

(4) Emergency Slope Inspection

Emergency Slope Inspection shall be carried out in case of emergency or after an earthquake or a heavy rainfall.

The objective of Emergency Slope Inspection is to check the slope condition in detail, and to make an appropriate response against landslides and to secure a quick traffic restoration. During this inspection, related weather information and traffic information shall be collected.

1.3 Scope of Application of this Guide

This Guide has been prepared for the purpose of the risk reduction of landslides through the development of the slope inspection for maintenance of roadside slope.

In view of circumstances in a lack of specialized engineers for slope stability, this Guide emphasizes the dissemination of an essential knowledge to the staff in charge of the road maintenance in Pakistan.

Furthermore, the Guide also covers emergency measures in a response to the urgent need of landslide risk reduction, since an appropriate and timely measure can prevent recurring landslides and help in the rehabilitation procedure.

Slope stability of natural slopes and cut slopes are difficult to be simulated because of the variability in topographic and geological condition of the slope. Importance of theoretical analysis and modeling estimation is undisputed. However, in application of the theory, abundant field experiences through slope inspection are required to assess slope stability precisely. Countermeasures based on continuous and careful observations of the subject slope are often superior to the application of the forepast theory. The users of this Guide are therefore advised to acquire a basic knowledge and skills needed for landslide risk reduction through slope inspection.

Chapter 2 Slope Inspection for Maintenance of Roadside Slope

2.1 Preparation of Slope Inspection

Necessary articles for the slope inspection are shown in Figure 2.1.

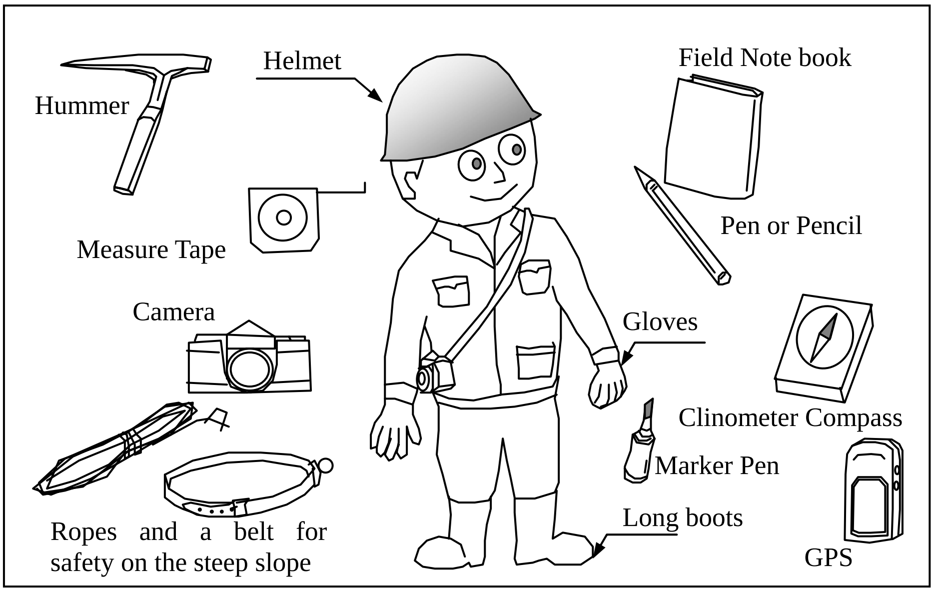


Figure 2.1 Necessary Articles for Slope Inspection (Reference: JH (1982), Slope Inspection Guide 1)

2.2 Regular Slope Inspection

2.2.1 Slope inspection

(1) Overview check

It is necessary to check from the spot with sweeping view for the comprehensive understanding of the slope phenomenon. You might be watching a little thing as shown in Figure 2.2.

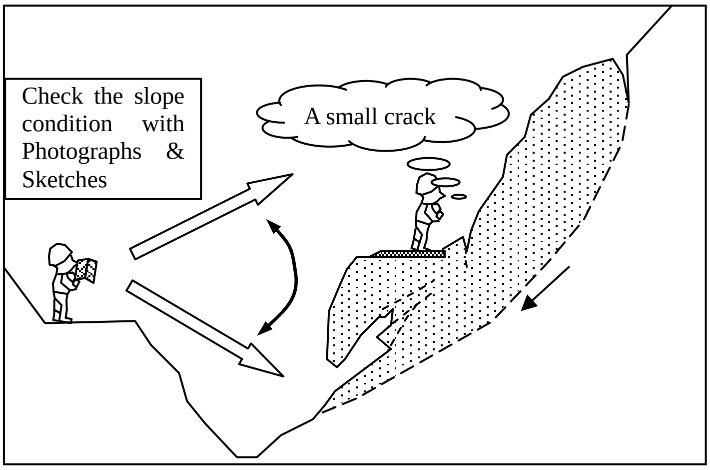


Figure 2.2 Importance of Overview Check from the Spot with Sweeping View for Comprehensive Understanding of the Slope Phenomenon (Source: JICA Study Team)

(2) Detailed Checking of Deformation on Roadside Slope

It is necessary to come close to the slope shoulder in the slope inspection, because most of landslides occur at slope shoulders. Some indications of landslides such as open cracks etc. might be found on the slope.

It is advisable to check the same slope twice (from its top and bottom) to avoid the chance of overlooking any symptoms of landslides as shown in Figure 2.3

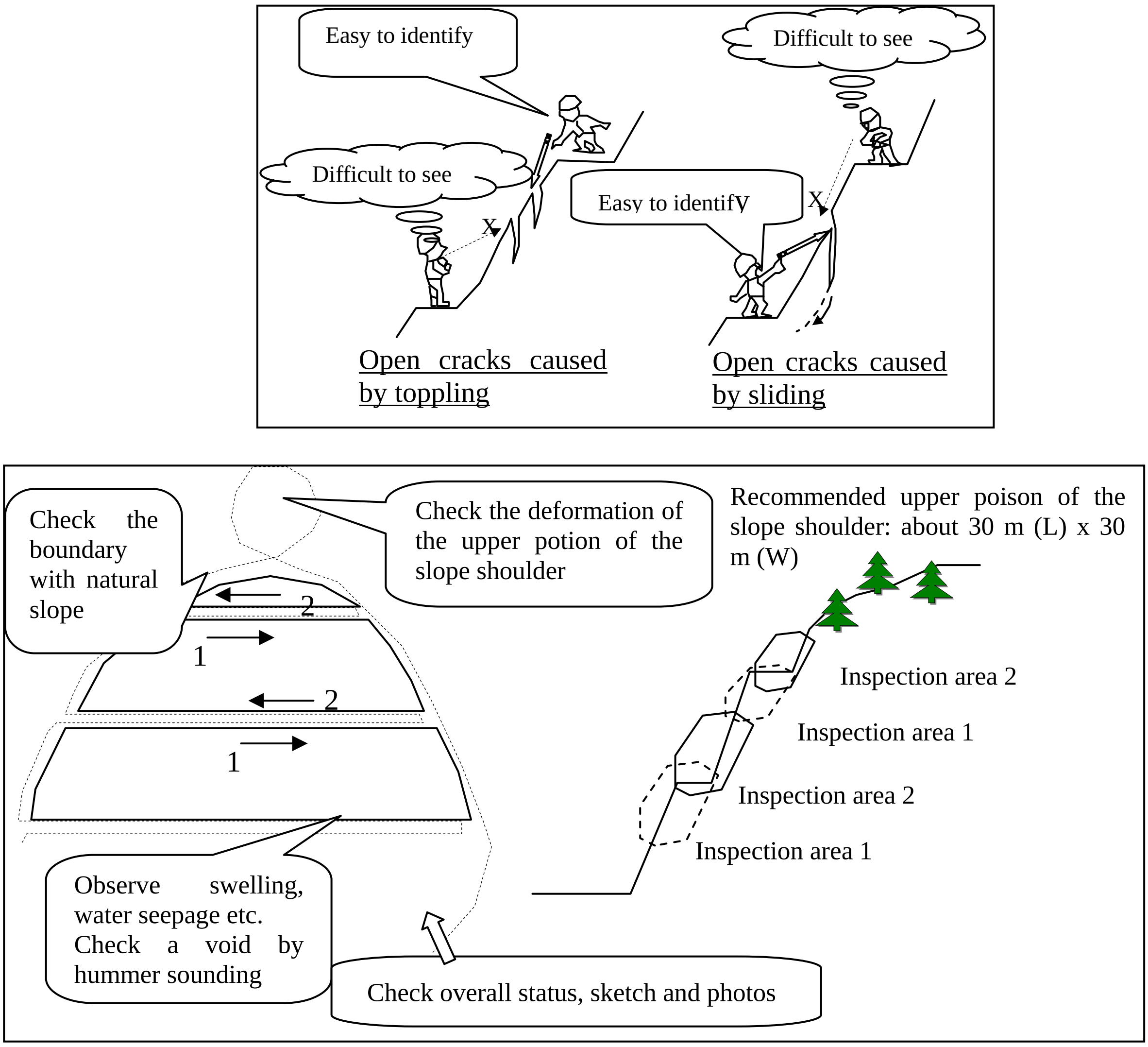


Figure 2.3 Points for Slope Inspection of an Existing Cut Slope (Reference: JH (1982), Slope Inspection Guide 1)

(3) Inspection Record

Any indications of landslides should be recorded in the Slope Inspection Sheet as shown in Appendix. A location map and coordinates/chainages are necessary for an inspection sheet, and photographs and sketches with dimensions of a landslide are important to evaluate disaster risk and to select appropriate corrective or countermeasures. The essence of the inspection sheet is summarized as shown in

Figure 2.4.

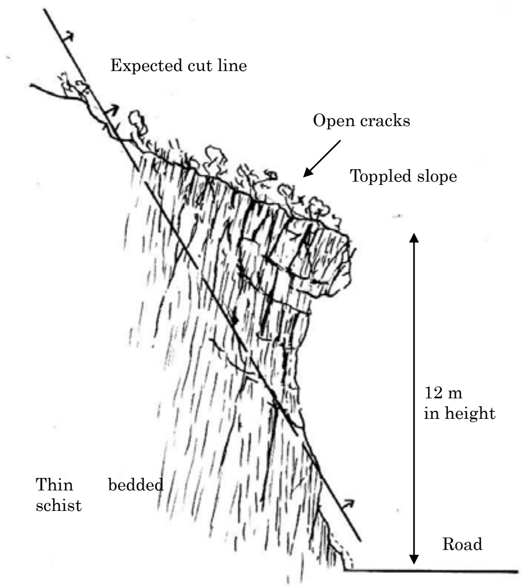
1. Road name N45
2. Coordinates N 34°33' 11.7", E 071°54' 44.3"
3. Failure type Rock mass failure/Collapse
4. Type of Slope Cut slope
5. Side of Road Left
6. Site Condition

- Toppled bedding plane, open cracks, and over hanging rocks on the slope were observed.
- Thin bedded and relatively fragile slate crops out.
- Cutting works by hand breaker is applicable.

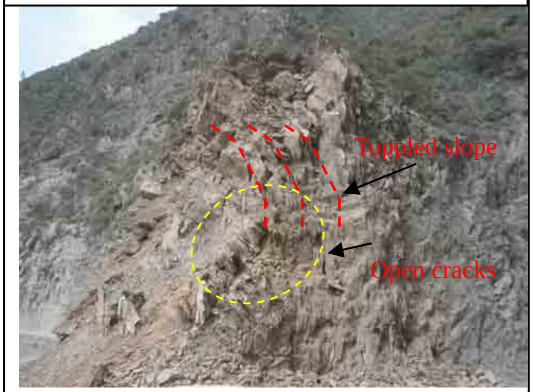
7. Recommendable Measures are:

To remove unstable toppled portions of the slope

8. Sketch of Slope



Location Map



Condition of Unstable Slope

Cutting Work Image

Figure 2.4 A Summary of Slope Inspection Sheets (Sample) (Source: JICA Study Team)

A laugh profile survey using a handy "Distance meter" and a "Clinometer compass" is highly recommended to be carried out for the comprehensive recognitions of a landslide as shown in Figure 2.5.

The detailed on the slope is determined using a measure tape etc.

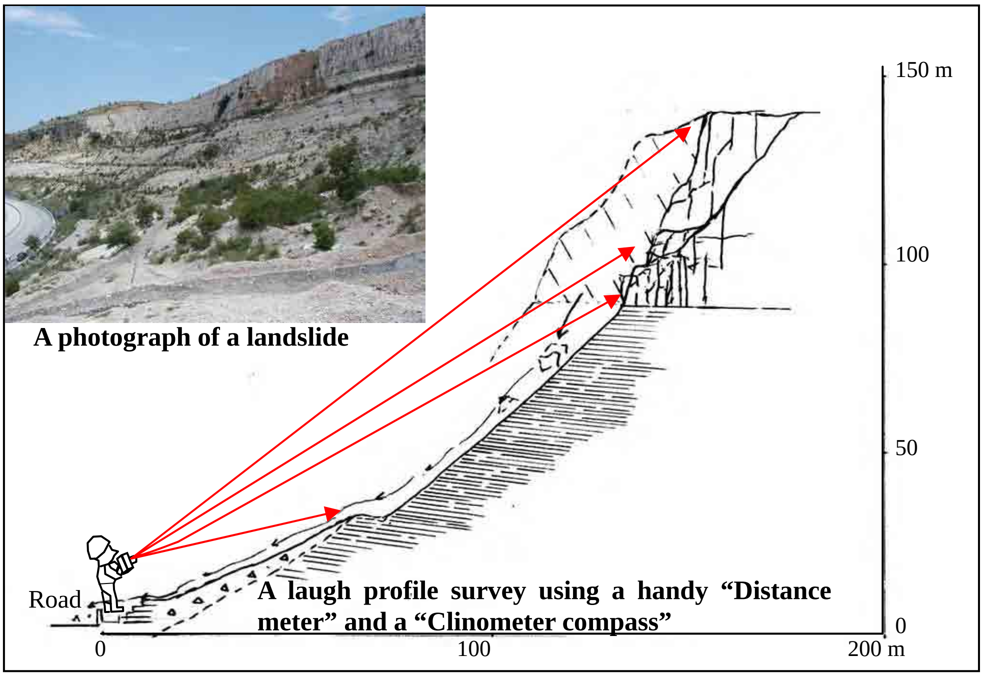


Figure 2.5　A Laugh Profiling Survey of Landslide (Source: JICA Study Team)

(4)　Slope Displacement Record

The displacement of a crack is recommended to be recorded in three different dimensions (X, Y and Z) as shown in Figure 2.6. Wooden battens and sticks will help to gather continuous data and to estimate the deformation rate as shown in Figure 2.7.

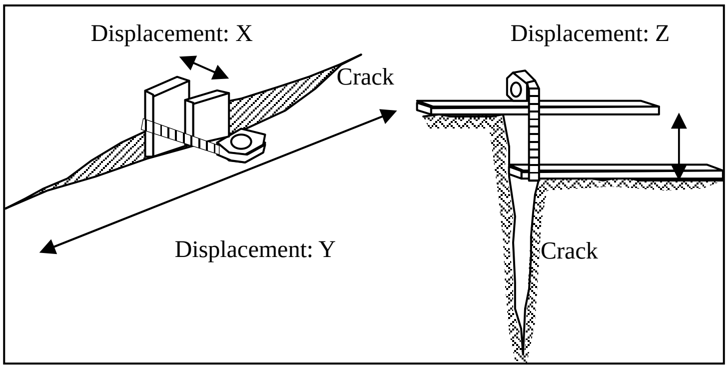


Figure 2.6　Displacement Measurement (Reference: JH (1982), Slope Inspection Guide 1)

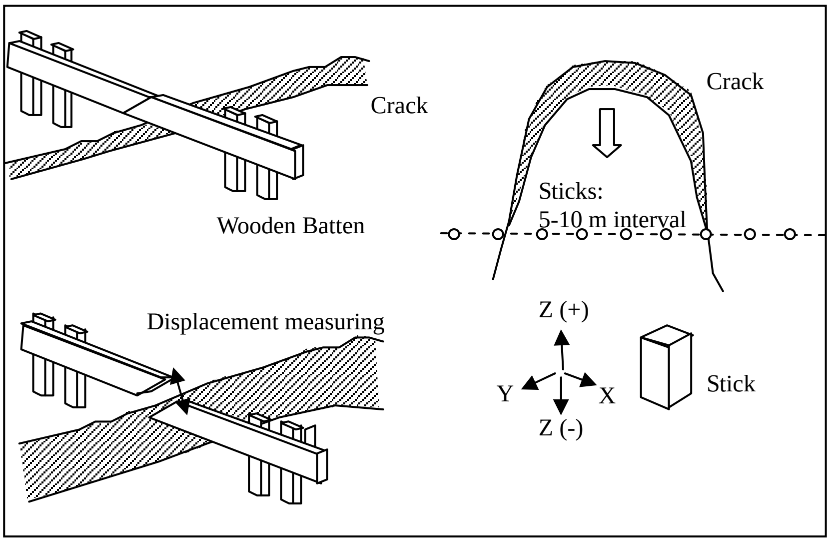


Figure 2.7 Displacement Measurement by Wooden Battens and Sticks, (Reference: JH (1982), Slope Inspection Guide 1)

2.3 Important Topographic/Geological Information for Slope Inspection

2.3.1 Phenomenal Proverbs and Lore of Natural Disaster

In the slope inspection, proverbs sometimes help us to detect significant factors in natural phenomena, although it should be noted that some of them might be inaccurate.

You may know some phenomenal proverbs or lore about “earthquake”, “spring water”, “snowfall”, “debris flow” and “landslide” etc.

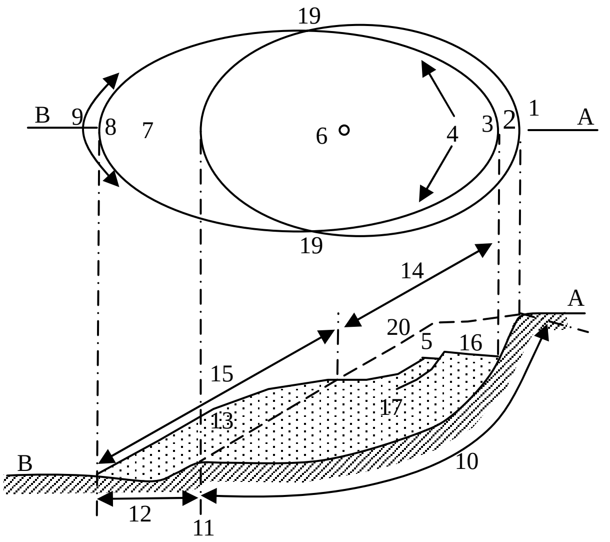
In case of Japan:

- Low groundwater level at shrine, whereas high level at temple.
- Leaning trees indicate a landslide.
- Bamboo trees like relatively wet condition, etc.

2.3.2 Topographic Information

(1) Landslide

Most landslides can be identified through topographic interpretation. Figure 2.8 gives a typical landslide landform and the definition of landslide features by the IAGE commission 1990.



Idealized Landslide Diagrams (1990 IAEG Commission on Landslide)

No.	Name	Definition
1	Crown	Partially undisplaced materials adjacent to highest parts of main scarp
2	Main scarp	Steep surface on undisturbed ground at upper edge of landslide caused by movement of displaced material(13, stippled area) away from undisturbed ground; it is visible part of surface of rupture(10)
3	Top	Highest point of contact between displaced material(13) and main scarp(2)
4	Head	Upper parts of landslide along contact displaced material and main scarp(2)
5	Minor scarp	Steep surface on displaced material of landslide produced by differential movements with displaced material
6	Main body	Part of displaced material of landslide that overlies surface of rupture between main scarp(2) and toe of the surface of rupture(11)
7	Foot	Potion of landslide that has moved beyond toe of surface rupture(11) and overlies original ground surface(20)
8	Tip	Point on toe(9) farthest from top(3) of landslide
9	Toe	Lower, usually curved margin of displaced material of a landslide, most distant from main scarp(2)
10	Surface of rupture	Surface that forms (or that has formed) lower boundary of displaced material (13) below original ground surface(20), mechanical idealization of surface of rupture is called slip surface
11	Toe of surface of rupture	Intersection (usually buried) between lower part of surface of rupture(10) of a landslide and original ground surface(20)
12	Surface of Sep.	Part of original ground surface(20) now overlain by foot(7) of landslide
13	Displaced Mat.	Material displaced from its original position on slope by movement in landslide; forms both depleted mass(17) and accumulation(18)
14	Zone of Dep.	Area of landslide within which displaced material(13) lies below original ground surface(20)
15	Zone of Acc.	Area of landslide within which displaced material lies above original ground surface(20)
16	Depletion	Volume bounded by main scarp(2), depleted mass(17), and original ground surface(20)
17	Depleted Mass	Volume of displaced material that overlies surface of rupture(10) but underlies original ground surface(20)
18	Accumulation	Volume of displaced material(13) that lies above original ground surface(20)
19	Flank	Undisplaced material adjacent to sides of surface of rupture; compass directions are preferable in describing flanks, but if left and right used, they refer to flanks as viewed from crown
20	Original ground	Surface of slope that existed before landslide took place

Figure 2.8 A Typical Landslide Landform and the Definition of Landslide Feature (after IAGE Commission 1990)

Many landslides (landcreep) have the following characteristics, according to experiences in Japan.

- Landslide area is bordered by head scarp(cracks), toe bulges and side cracks
- Movement direction is perpendicular to the head scarp and almost parallel to side cracks
- Depth of sliding surface is approximate the 1/7 to 1/10 of the width of landslide

Figure 2.9 gives the three different morphologic features of landslides.

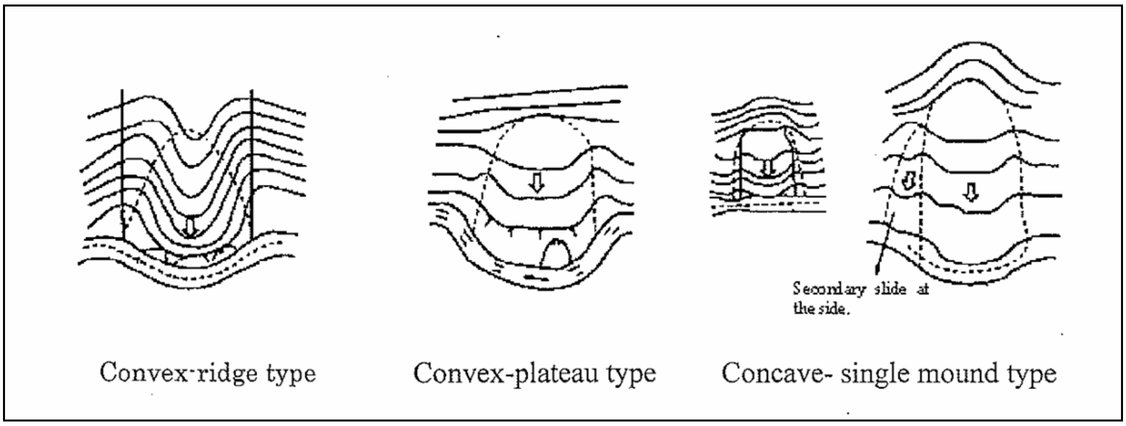


Figure 2.9 Topographic Characteristics of Landslide (Landcreep) (After Watari et al., 1987)

(2) Fault

Mountainous roads are sometimes proposed to lie on a series of saddle/wind gap (called a lineament topographically) to reduce cut volume. However, these areas are suspected to be fractured and deteriorated due to weathering or hydrothermal alteration, where a large cut at toe of slope might trigger a landslide.

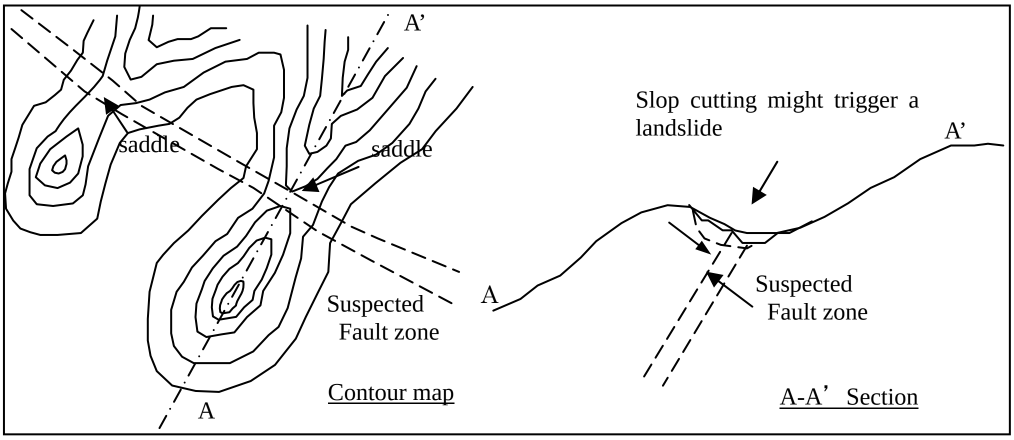


Figure 2.10 Typical Topographic Feature of A Fault (Reference: JH (1982), Slope Inspection Guide 1)

(3) Break Line of Slope

Many existing mountainous roads lie on or near the shoulder of the natural slope (break line of the slope), and the combination technique of the slope cut and embankment is used to secure necessary road width and to minimize the earthwork volume as shown in Figure 2.11.

Some gully erosions formed by water seepage beneath break line often induces a road embankment failure.

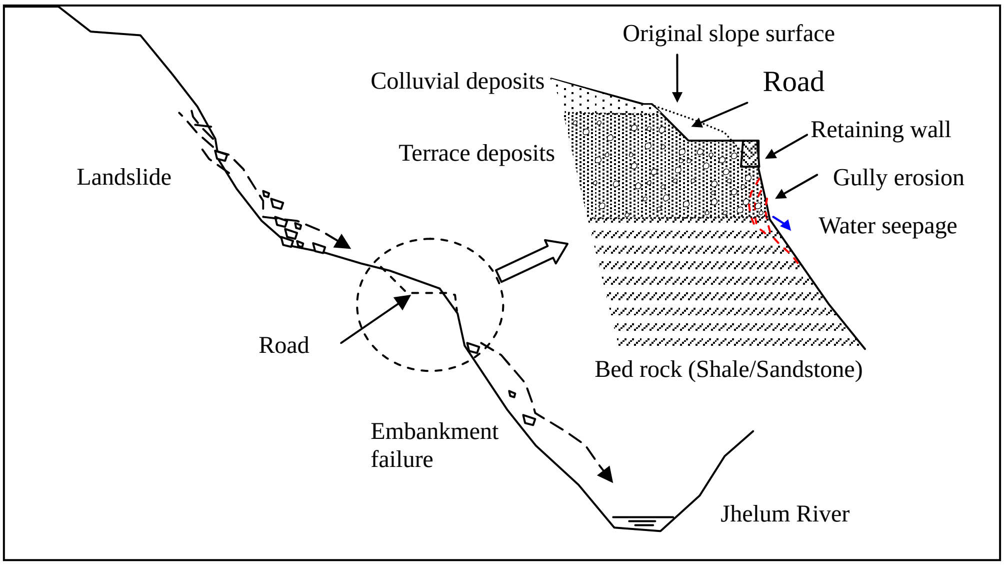


Figure 2.11 A Schematic Profile of Jhelum Valley Road and Landslide Image (Source: JICA Study Team)

(4) Alluvial Fan

Even if no water drainage in dry season, a road crossing an alluvial fan might suffer debris flows in wet season. Occurrence of debris flows seems to increase after the earthquake.

A debris flow occurred at about 3:00 a.m., on July 24, 2006 during heavy rainfall in Chehla Bandi of Muzaffarabad City. Thirteen people (Two families) in shelter tents were killed. The width of the river is only 3-5 m upper stream of the alluvial fan and little water drainage under ordinary conditions.

Some alluvial fans are identified at the foot of mountains. The distribution of the alluvial fan deposits indicates the past repeated incidents of debris flows (See Figure 2.12).

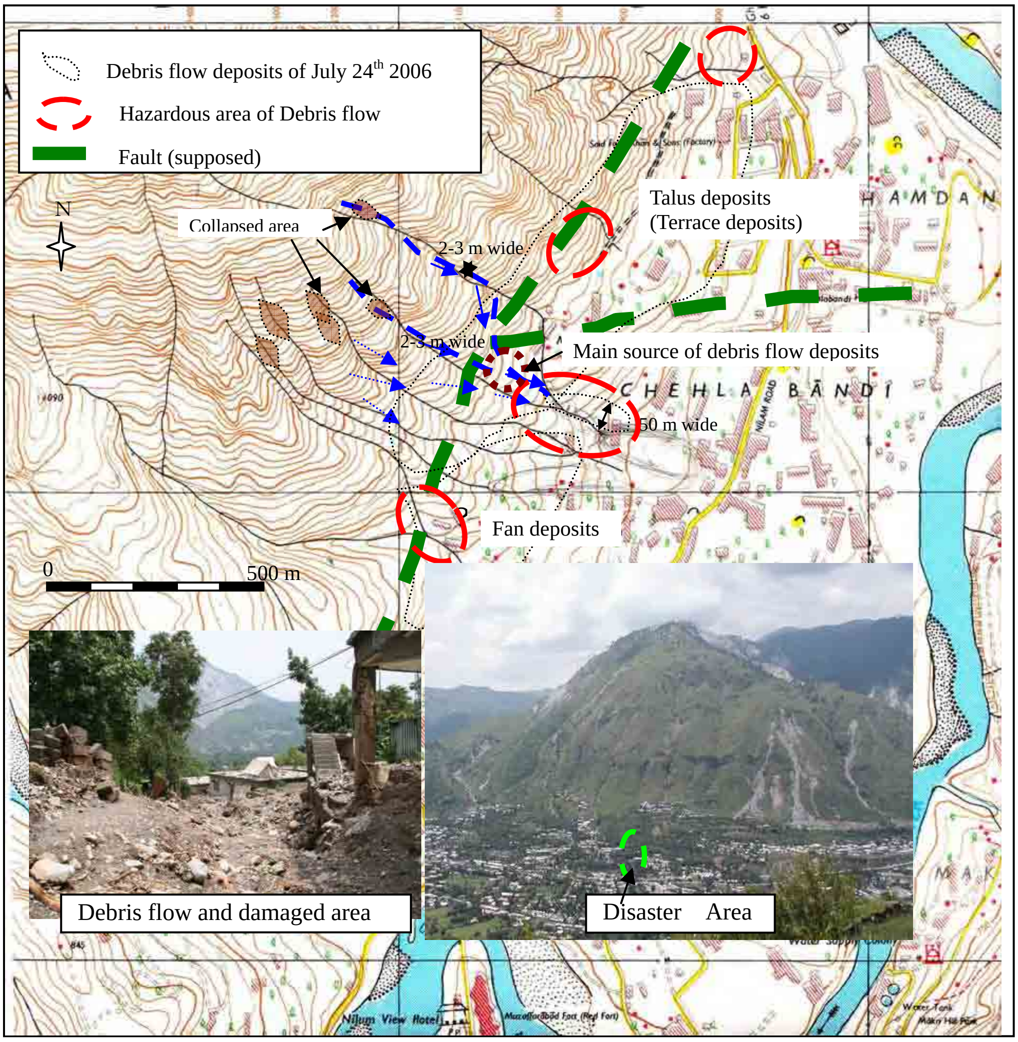


Figure 2.12 Debris Flow Hazardous Area (Source: JICA Study Team)

(5) Indication of Landslide

The following phenomenon/indicator is helpful to identify landslide-prone slopes.

- Open cracks, Erosion
- Dying trees caused by developed tension cracks (See Figure 2.13).
- Leaning trees caused by the creep of the slope surface.
- Spring, water seepage etc.

In slope inspection some check lists of phenomena or indicators are helpful to identify landslides. A sample of the list to observe a landslide is shown in Table 2.1.

Figure 2.13 Dying Trees Caused by a Landslide beside Murree Road (Source: JICA Study Team)

Table 2.1 Sample of Observation Sheet for Landslide

Observation Sheet No. 2 Ref.

1. General

Date/Time 13/09/2006 10:00 , Observed by

Weather cloudy ,

Location: Route N45 N 34°33’ 02.07”, E 071°54’ 30.8” (by handy GPS)

2. New Findings/Unusual Condition at the Site_____ Check, if any

1) Slope

Head scarp □ Cracks ☑ Erosion □

New collapse □ Leaning tree ☑ Spring □

2) Drainage Ditch

Blockage by soils □ Deformation □ Swamp □

3) Gabion work/Masonry wall

Deformation □ Cracks ☑ Scour of foundation □

4) Road

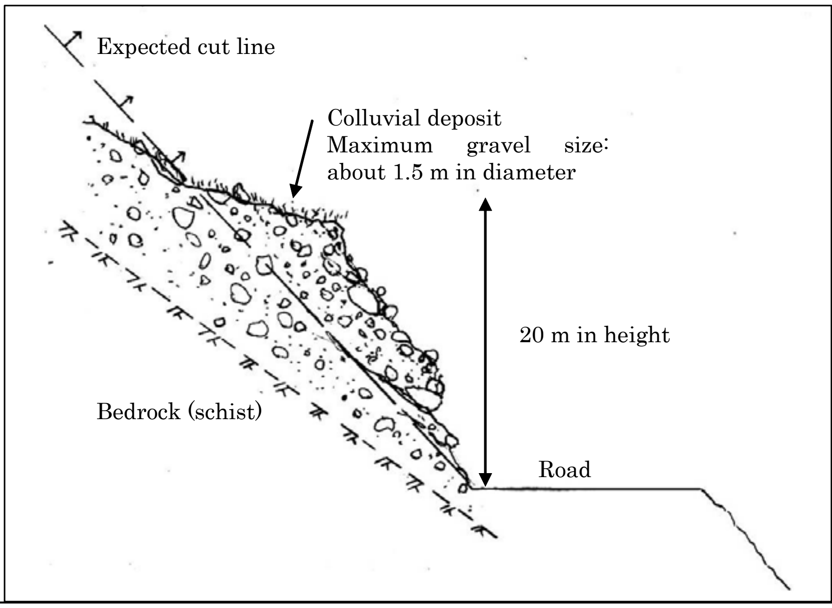
Cracks □ Settlement □

5) Mountain stream

Debris □ Collapse ☑ Change of water level □

Driftwood □ Embankment failure □

Sketch or Photograph of New Findings/Significant Deformation (with dimensions)



Source: JICA Study Team

2.2.3 Geological Factor of Landslide-prone Slope

(1) Water Infiltration from Drain

A drain of the slope shoulder or loading of road above sometimes deteriorates the cut slope. Infiltration from a drain sometimes causes a landslide.

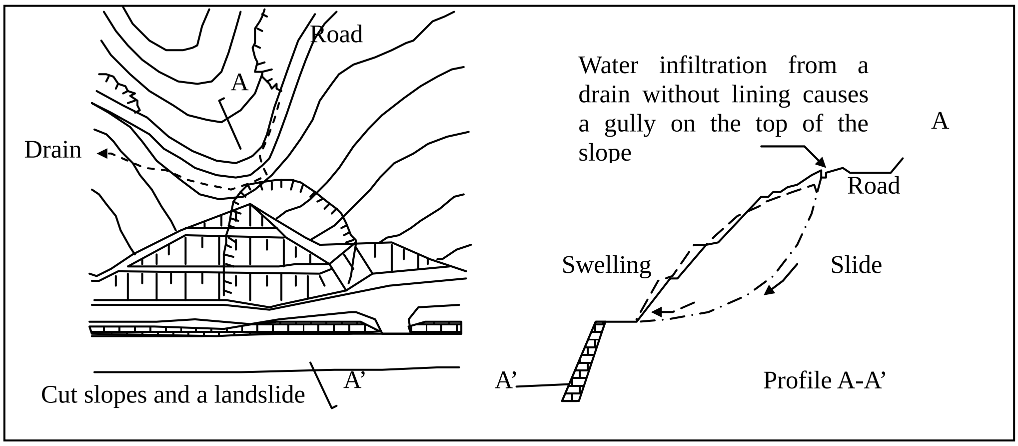


Figure 2.14 A Landslide Caused by the Improper Road Gully above the Cut Slope (Reference: JH (1982), Slope Inspection Guide 1)

(2) Geological Boundary

Water seepage from a geological boundary is a major mechanical factor of the landslide. A geological boundary sometimes forms a deteriorated and loosened zone. Along Jhelum Valley and in Muzaffarabad City, enormous landslide occurs in the following combination of the geological boundary.

- Unconsolidated deposits (debris/talus deposit and terrace deposit)
- Unconsolidated deposit (mainly terrace deposit) and bedrock (shale/ schist rocks)

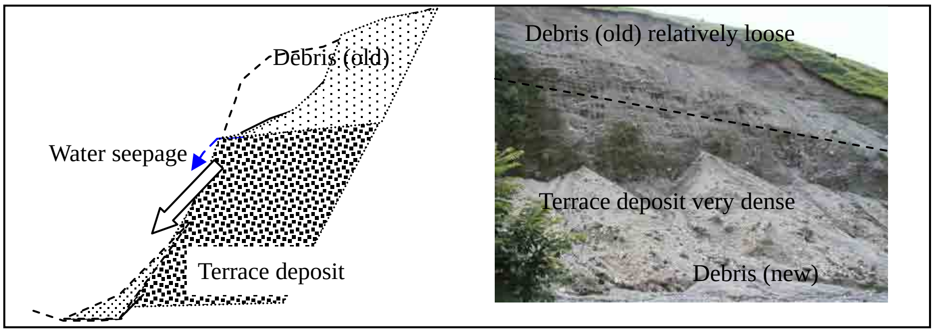


Figure 2.15 A Landslide observed at A Geological Boundary (Source: JICA Study Team)

In Muzaffarabad City, many landslides of the old debris deposits have occurred. Although surface of the debris is well-cemented by calcium, yet this surface was vulnerable to the earthquake damages and many open cracks are distributed on the surface. Inside materials of the debris are relatively loose and the seepage from the geological boundary further deteriorates the slope stability. Meanwhile, most of the terrace deposit is very dense and remains stable even after the earthquake.

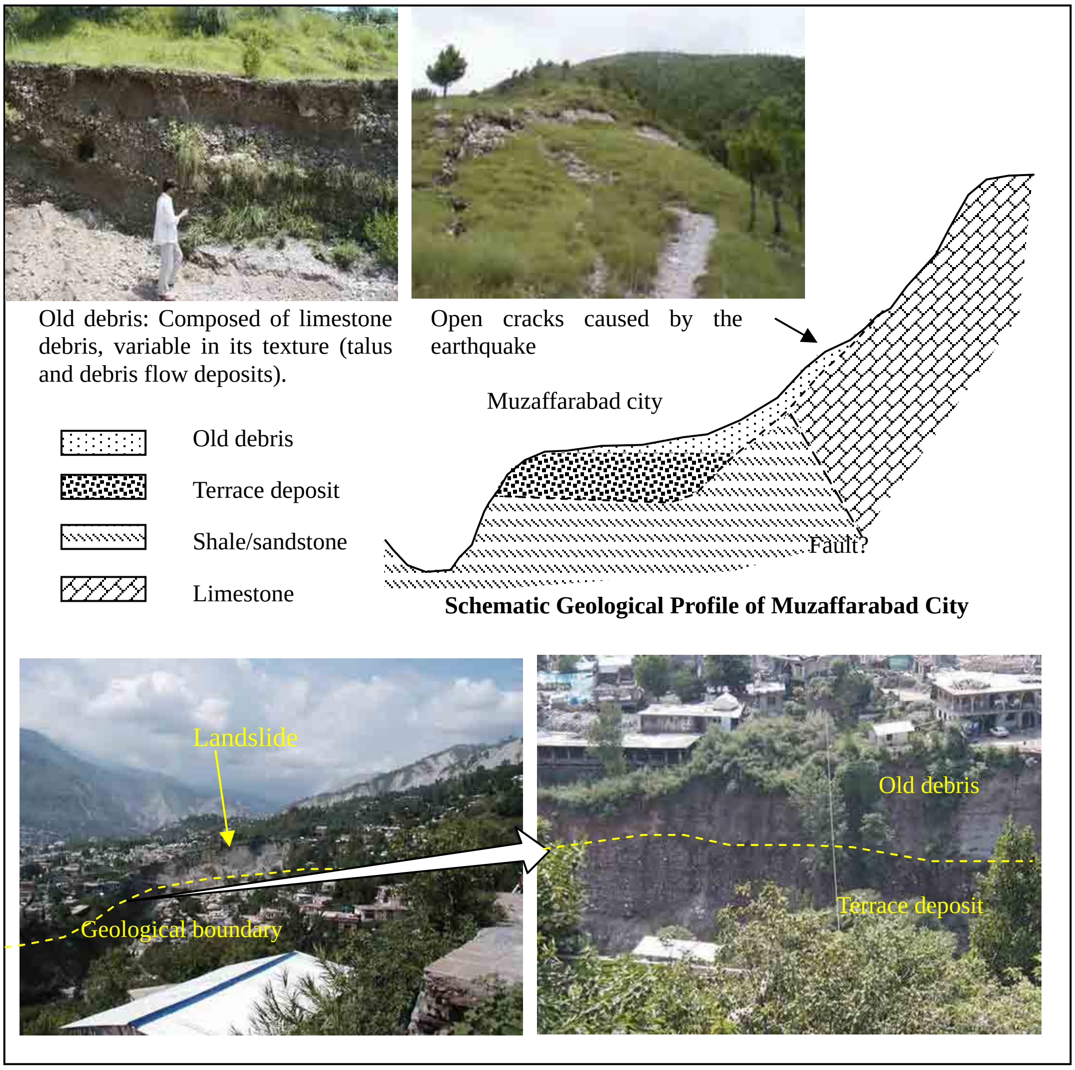


Figure 2.16 Geology and Landslide prone Area in Muzaffarabad City
(Source: JICA Study Team)

The distribution of the vegetation helps to identify seepage from a geological boundary.

Figure 2.17 Seepage from the Geological Boundary
(Source: JICA Study Team)

(3) Geological Structure

Bedding plains of bed rocks along the Jhelum River are folded in variable orders. Landslides are subjected to the geological structure of rock slopes as shown in Figure 2.18.

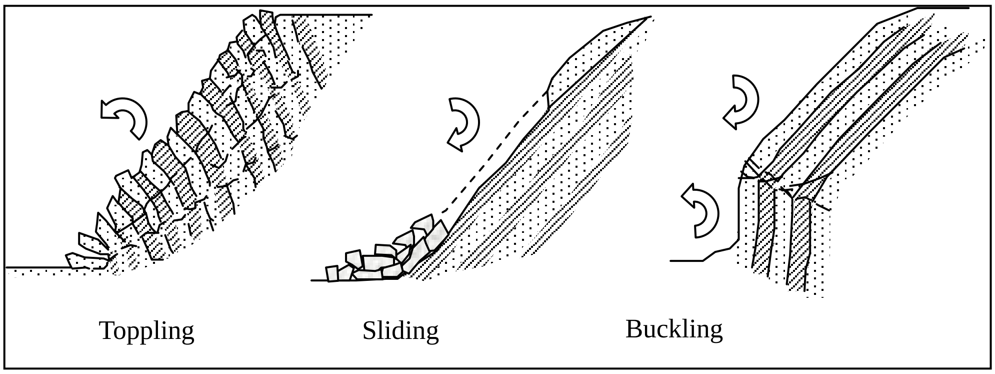


Figure 2.18 Three Types of Landslides on Rock Slope (Source: JICA Study Team)

In case of Hattian landslide, which took out during the earthquake, soil and rock mass slid on the surface of synclinal folded bedrocks as shown in Figure 2.19.

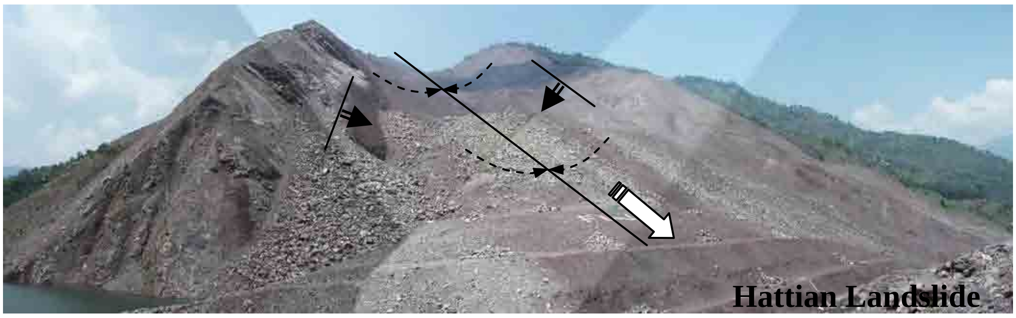


Figure 2.19 Hattian Landslide (Source: JICA Study Team)

(4) Inclination of Slope and Landslide

Steep slopes, particularly the slope shoulders and convex slopes are vulnerable to damage by the earthquake. An image of progressive extension of landslide area at the slope shoulder damaged by earthquake is shown in Figure 2.20.

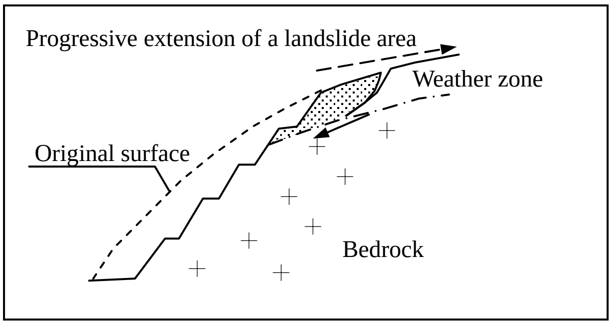


Figure 2.20 An Image of Progressive Extension of a Landslide Area at the Slope Shoulder Damaged by Earthquake (Reference: JH (1982), Slope Inspection Guide 1)

On the other hand, gentle slopes are apt to be subjected to raindrop erosion or landslides induced by rainfall.

Standard gradient of cut slope in general is 1:1.0-1:1.2 for soil, 1:0.8 for soft rock and 1:0.5 for hard rock respectively. According to Japan experiences, many landslides occur on the cut slopes at the gradient of 1:0.8-1:1.2 after completion of slope protection works. Probably such landslides are caused by improper slope gradient, because the boundary between soil and soft rock including weathered rock is complicated and variable in general.

Many cut slopes at the gradient of more than 1: 0.5 are relatively stable after completion of slope protection works, since unstable soil/rock mass on steep slope is apt to fall during cutting works and steep slope can reduce direct hits of raindrop.

Meanwhile, enormous landslides (landcreep) occur on the slope of Jhelum Valley Road and N-75 (Murree-Muzaffarabad) road along the active fault line even if the gradient is less than 1:1.5 as shown in Figure 2.21. Reddish swelling clay is the main factor of recurrent landslides (landcreep) during and after rain falls.

Figure 2.21 Reddish Swelling Soil beside N-75
(Source: JICA Study Team)

(5) Recurrence of Landslide (Landcreep)

Once damaged by the earthquake, any heavy rainfall or abnormal weather phenomenon thereafter, causes a landslide (landcreep) very often and recurrently.

During the 2006 wet season, a landslide (landcreep) moved gradually after the heavy rainfall (more than 100 mm/day of 4th Aug 2006) and had crept for the next one week in spite of the no rain fall. Some houses were seriously damaged from 6th Aug to 8th Aug, 2006 as shown in Figure 2.22.

Damaged residential building

Figure 2.22 Recurrence of An Old Landslide (Landcreep)
(Source: JICA Study Team)

(6) Soil Characteristics of Landslide-prone Slope

1) Collar

Reddish or greenish soil caused by alteration, and the black clay caused by faults are the major geological characteristics of the landslide-prone slopes in the Oct 8th Earthquake affected Areas.

2) Particle Size/Consistency

In general, cohesive soil (clay) shows low water permeability, high natural water content and poor drainage, and sandy materials show high water permeability, low natural water content, and good drainage. Meanwhile, silt, medium size between sand and clay, shows low water permeability, low plasticity, and poor drainage in spite of relatively high absorption. These characteristics of silt are unsuitable for slope stability.

Medium content ratio area of fine materials (silt & clay) shows slope instability, and increasing or decreasing ratio of fine materials works to stabilize the slope (See Figure 2.23).

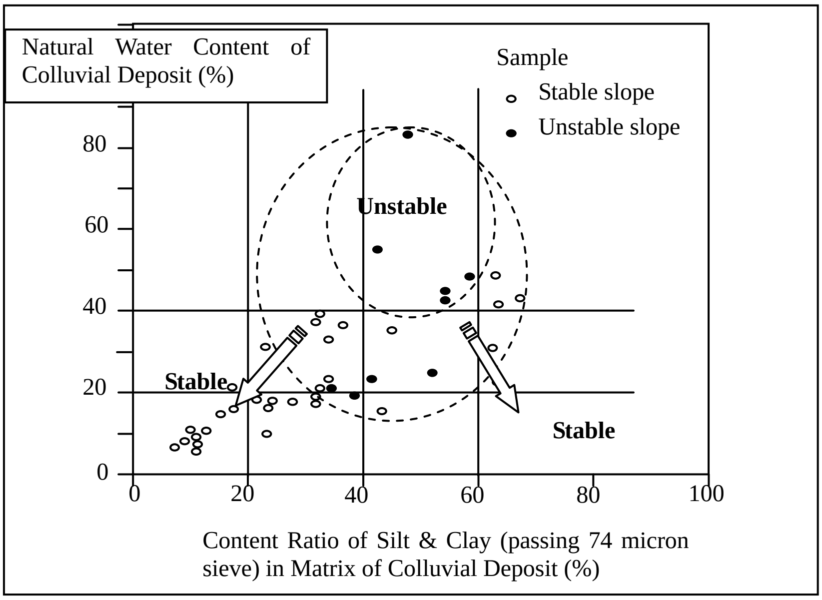


Figure 2.23 Cut Slope Stability of Colluvial Deposit Based on Natural Water Content and Content Ratio of Silt and Clay (References: Okusono, 1979, JH lab report)

2.4 Point for Slope Inspection

2.4.1 Early Research and Quick Response

Early identification of slope deformation and quick response is necessary to achieve slope disaster reduction. Although deformations of slope will not always lead to catastrophic landslides, monitoring of the deformation will help to take proper measures and early repair works against damaged slopes which can consequently reduce the road maintenance cost.

2.4.2 Open Crack of Slope Shoulder

Extension cracks of slope shoulder indicate deformation of the subject slope. Infiltration of rainfall through the cracks will further accelerate the process of the landslide. Therefore, crack filling by soil or mortar etc. and then covering these cracks by plastic sheets are advisable to mitigate slope disaster. Besides, these mitigation works are necessary to be followed up by monitoring of deformation on the slope.

Numerous open cracks are found existing at the slope shoulders of the slopes damaged by the earthquake in Muzaffarabad area (See Figure 2.24). Deformation monitoring of these cracks is highly necessary and is recommended to undertake preventive or corrective measures to reduce landslide risks. A typical spreading process of the development of open cracks on a slope shoulder is shown in Figure 2.25.

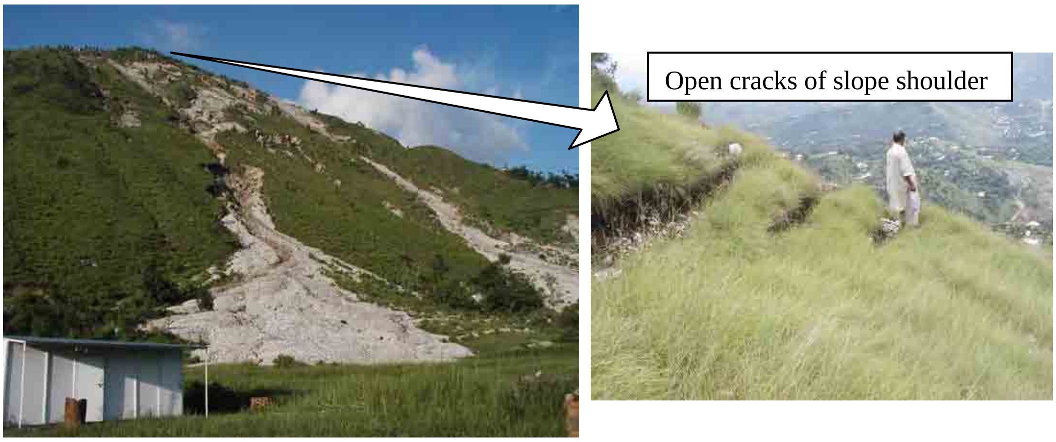


Figure 2.24 Two Debris Flows of 2006 Wet Season and Tension Crack of Slope Shoulder in Muzaffarabad City (Source: JICA Study Team)

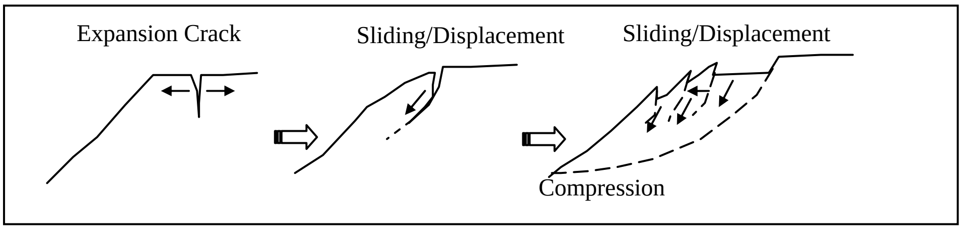


Figure 2.25 A Typical Spreading Process of Development of Open Cracks on a Slope Shoulder (Reference: JH (1982), Slope Inspection Guide 1)

2.4.3 Gully Erosion

Sandy or silty soil slopes are subject to the phenomenon of gully erosions. In general a gully becomes deeper and wider through the under mentioned processes as shown in Figure 26, and consequently leads to landslides.

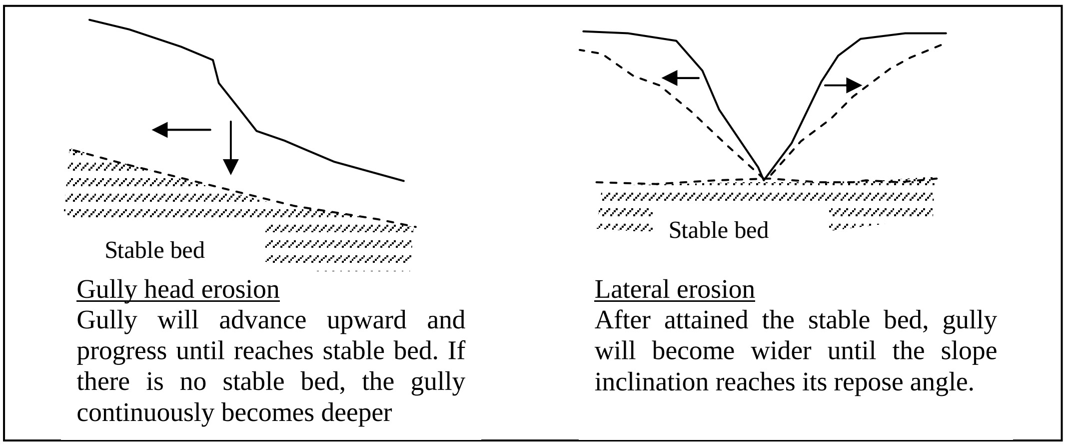


Figure 2.26 Advance of Gully Erosion (Source: JICA Study Team)

Leakage from inadequately installed ditches beside berm of road also causes gully erosion. Countermeasures against this gully erosion are:

- To apply lining for the damaged ditch to prevent water infiltration,
- To infilling gully with gravel/crushed stone, or mortar and to install gabion if necessary
- To install proper longitudinal drainage

2.4.4 Piping

Piping at the toe of slope causes embankment failures. Embankment of concave slope which indicates high ground water level (watery ground) is advisable to be monitored regularly. Figure 2.27 gives an embankment failure caused by piping at the toe of slope and its countermeasure image

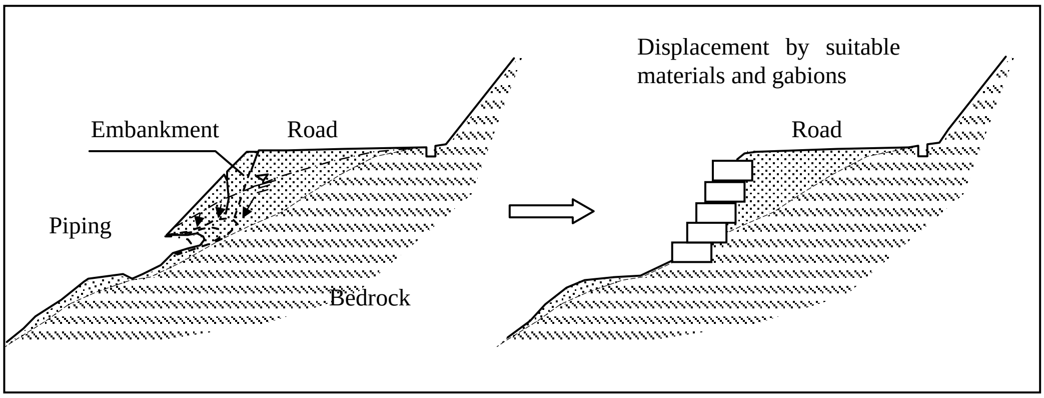


Figure 2.27 Embankment Failure caused by Piping at the Toe of Slope and Its Countermeasure Image (Source: JICA Study Team)

2.4.5 Embankment Failure caused by River Bank Erosion

Embankment failures caused by riverbank erosion sometimes results in immense harm to road traffic, since their maintenance works are technically and ecumenically difficult due to its scale as shown in Figure 2.28. An early identification and a quick response are necessary. Hazardous areas of riverbank erosion should be observed carefully in the slope inspections.

Figure 2.28 Embankment Failure caused by River Bank Erosion on Jhelum Valley Road (Source: JICA Study Team)

2.4.6 Swelling at the Toe of Slope

Swelling at the toe of slope indicates the slope creeping (See Figure 2.29). Swelling of slope frequently is associated with water seepage at the toe of the slope and the existence of tension cracks above.

Figure 2.29 Swelling of Toe of slope on Jhelum Valley Road (Source: JICA Study Team)

2.4.7 Water Drain Pipe

Drained off water sometimes leaves carbonate or red ocher traces on the surface of retaining walls. Bedrocks behind the walls might be loosened and slope stability be deteriorated, because intermittent alternate wetting and drying accelerates the weathering of bedrock. Grass growing in a drain pipe of a retaining wall needs to be removed for slope stability, because the grass obstructs proper water drainage and will lead to water pressure increasing behind the wall (See Figure 2.30).

Figure 2.30 Grass Growing in Drain Pipes of the Retaining Wall (N-75) (Source: JICA Study Team)

2.4.8 Deterioration of Protected Slope

Shotcrete is effective slope protection for jointed or erosive rocks; however, shotcrete material itself will be deteriorated with time and might flake gradually. Besides, spring water would form a void behind the concrete or mortar coating the slope. The void can be identified through sounding by a hammer, also infrared photographs are useful.

2.4.9 Water Seepage from Top or Joint of Retaining Wall.

Retaining wall needs to be backfilled by pervious materials. Consequently groundwater of the wall can drain off through the backfill materials.

In case that water seeps from the top or joints of the retaining wall, it will be caused by inadequate drainages and the resultant hydrostatic pressure might lead to a landslide. Provision of horizontal holes is advisable for discharging the trapped water behind the retaining wall.

2.4.10 Horizontal Crack on Concrete Structures

Concrete structure often suffers random cracks or longitudinal cracks because of desiccation shrinkage in itself or interim deformation of its foundation immediately after completion of the structure. However, these cracks do not always lead to a landslide directly. Sealing by mortar etc., to prevent infiltrating water, could secure the slope stability. Meanwhile, horizontal cracks often indicate swelling of toe of slopes and may lead to a landslide.

2.4.11 Inadequate Water Drain

Inadequate water drain frequently leads to damages of cut slopes and embankments. Even adequate water drains might deteriorate with time. The following drains are inadequate for drainage and need repair works

(1) Exposed Drain Ditch Scoured by Surface Water

A drain ditch scored by spilt water over the drain has a high potential of a landslide. Early repair works of the drain is advisable as shown in Figure 2.31.

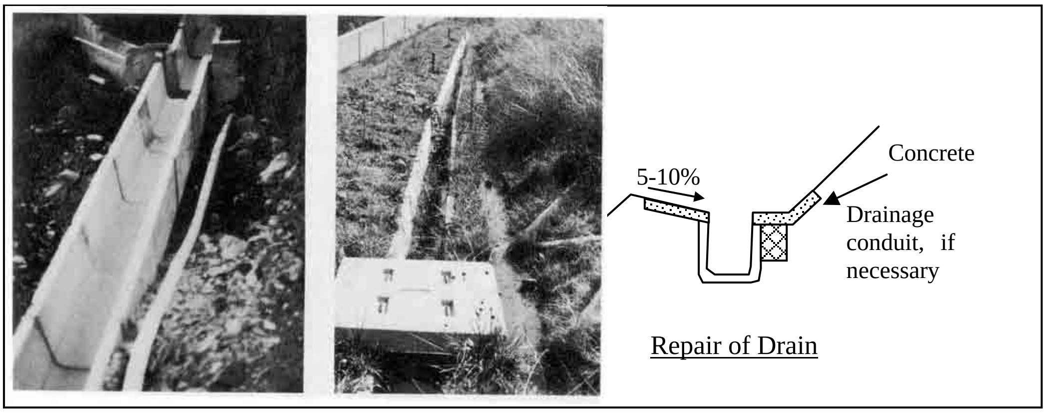


Figure 2.31 Scouring and Repair of Drain (Source: JH (1982), Slope Inspection Guide 1)

(2) Leakage from Drain

Water leakage often occurs from some joints of a drain as shown in Figure 2.32. Overflow water causes gully erosion.

Figure 2.32 Water Leakages from a Joint of Drain and Erosion (Source: JH (1982), Slope Inspection Guide 1)

(3) Blockage of Drain

Soil or plant residue frequently blocks adequate drainage, and over flow causes gully erosion or a landslide. Regular cleaning of drain and erosion control by plant treatment etc. in such cases is advisable.

(4) Inadequate Longitudinal Drain

Leakage of longitudinal drain and hydraulic jump or overflow due to the capacity shortage of discharge water also cause gully erosion. Figure 2.33 shows a sample of repairing works of the damaged drain.

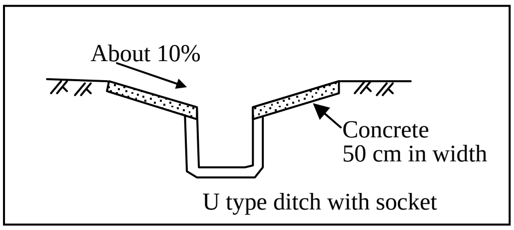


Figure 2.33 Repair of Longitudinal Drain Damaged by Surface Water (Source: JH (1982), Slope Inspection Guide 1)

(5) Capacity of Drain

Capacity of drain on the slope shall be adequate for required water discharge. Besides checking design capacity, actual drainage should be observed to secure the slope stability in case of higher cut slope or the slope backed by a large catchment area.

2.4.12 Fixed-Point Observation of Landslide-prone Slope

The monitoring of a landslide-prone slope from the fixed point helps to identify unstable soil/rock mass on the subject slope and to undertake proper and timely countermeasures. Marking the fixed monitoring points on ground will make it easy to find the same later (See Figure 2.34).

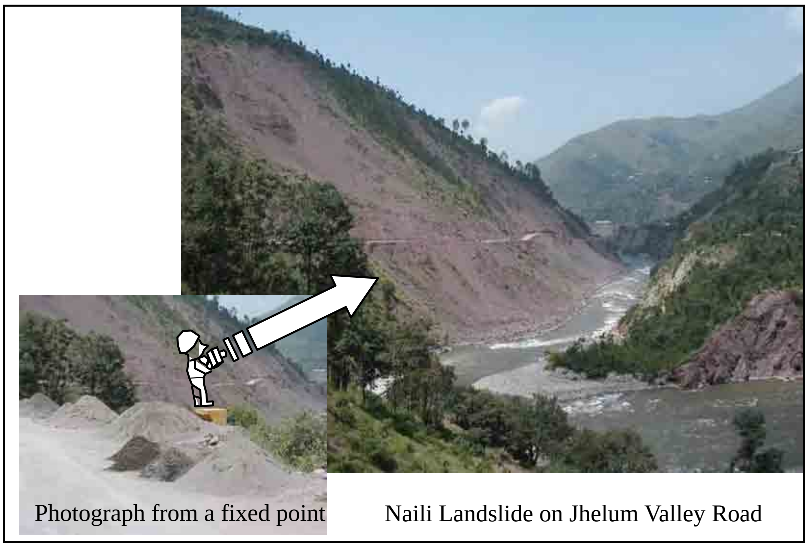


Figure 2.34 Monitoring of Landslide Area from a Fixed Point (Source: JICA Study Team)

2.5 Emergency Countermeasure

2.5.1 Preparation

In addition to necessary articles in routine activity, the equipments as shown in Figure 2.35 are recommended for a quick response against slope disaster.

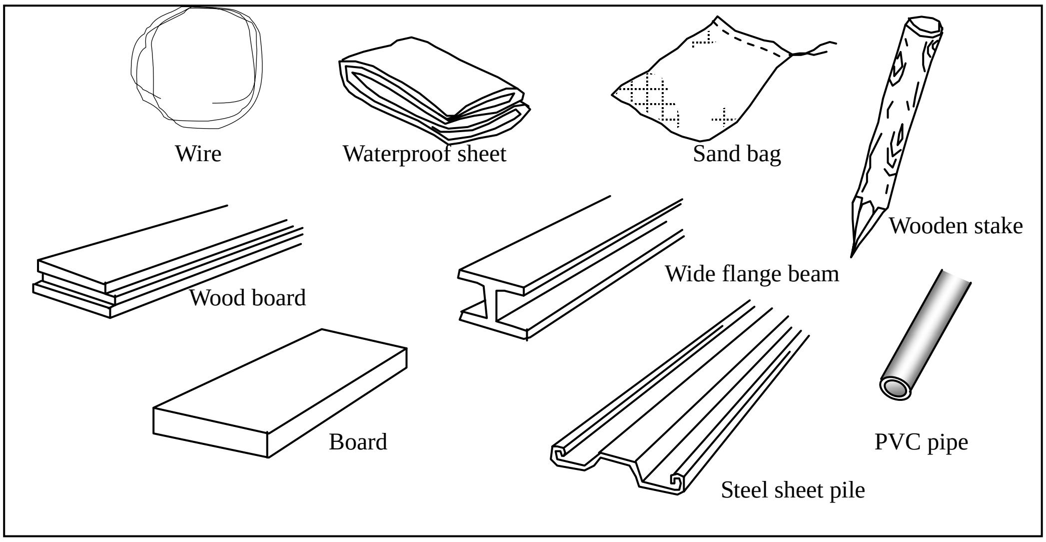


Figure 2.35 Equipments of Quick Response for Slope Disaster Prevention (Source: JH (1982), Slope Inspection Guide 1)

In addition, it is necessary to collect weather forecast, rain precipitation data and information of traffic flow in advance.

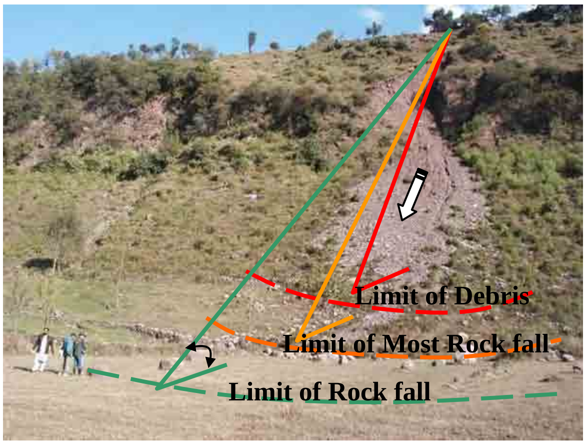
Furthermore, since in a time of disaster necessary information sharing with all relevant agency and public department is important for quick response, communication system in emergency is recommendable to be prepared in advance.

2.5.2 Emergency Measures

(1) Extent of the Impact of Debris and Falling Rocks

3) Debris

According to Japan experiences, it is known that extent of about 90% debris is within a distance equal to the slope height, and almost of debris stop within twice of the slope height (See Figure 2.36) .



Dense of debris decreases in accordance with the distance from the collapsed slope.

Figure 2.36 Classification of Affected Area of Landslide (Source: JICA Study Team)

Landslide-prone slopes composed mainly of terrace deposits are distributed along the Jhelum River. Slope stability is subject to topographic features and geological conditions, which are regionally variable. Therefore further study of the debris affected area will help to undertake preventive and corrective measures against landslides.

4) Rockfall

According to Japanese experiences of rock falls, mostly height of the bounding stone is within two meters regardless of the slope length, in case there are no extreme projections (See Figure 2.37).

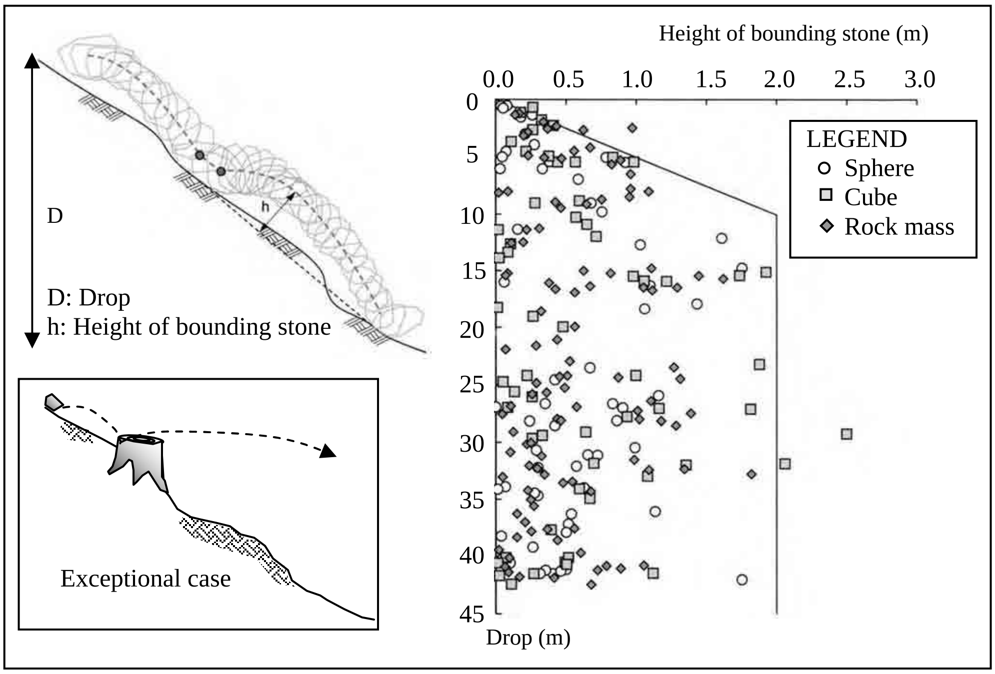


Figure 2.37 Height of Bounding Stone (Source: Nikkei Construction, 2006)

(2) Emergency Measures

Keeping out water will mitigate slope disaster. Advisable emergency measures to prevent the damage of spreading are (See Figure 2.38):

- To cover the landslide area by plastic sheets to keep out water,
- To install sand bags at the toe of the slope to stabilize the slope and
- To install a couple of drains

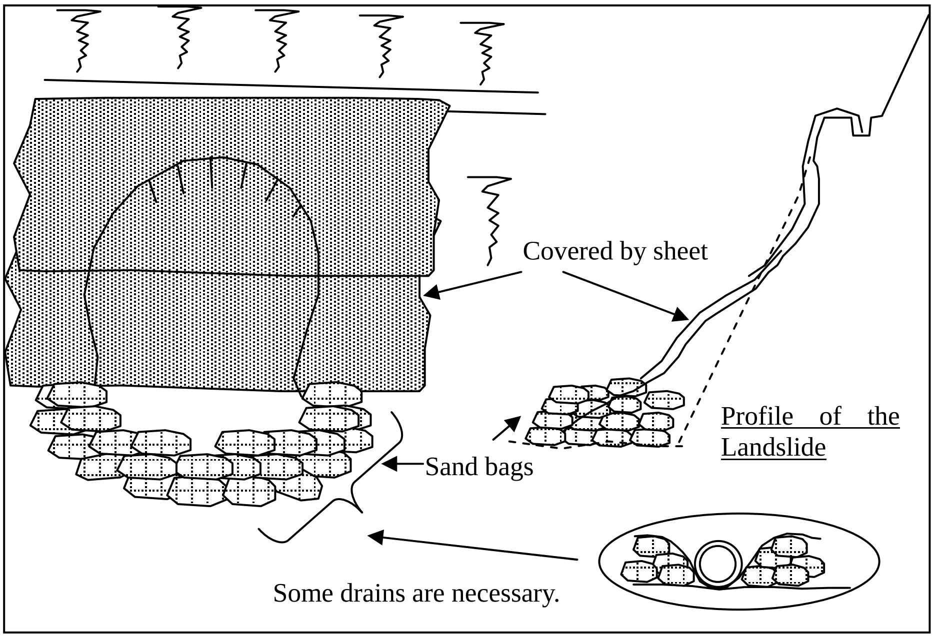


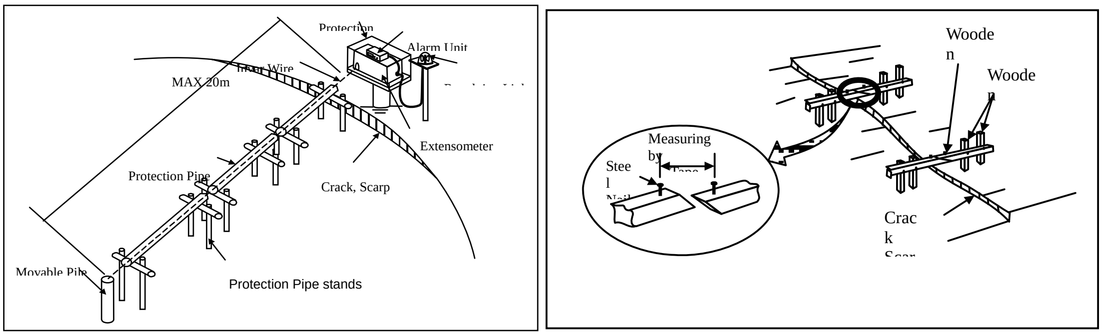
Figure 2.38 Emergency Measure Image against a Landslide (Source: Slope Inspection Guide 1, 1982, JH)

(3) Reopening of Traffic

Removal of debris on road might trigger a new landslide. Prior to and during debris removal works, slope inspection is important to prevent slope disaster.

2.5.3 Monitoring

Although it is necessary to take drastic measures, such as execution of landslide countermeasures, yet the drastic measures require great time and cost. Therefore, it is indispensable to develop and implement a warning and traffic control system to prevent and mitigate road slope disaster. Monitoring of the landslide-prone slope is the first step for a timely and appropriate traffic control. Monitoring equipments of landslides are shown in Figure 2.39.



An extensometer installed at a landslide — Wooden batten to measure deformation of a landslide

Figure 2.39 Monitoring Equipments of Landslide (Source: JICA Study Team)

These standard values for warning should be set in accordance with the site condition and improved as rainfall and displacement information is collected from the installed equipment. For reference, warning level of installed monitoring system in Muzaffarabad city in the wet season after the earthquake is shown in Table 2.2.

Table 2.2 Standard Values (Sample)

Warning Level	Standard Values	Monitoring Method	Monitoring Frequency
Normal	Rainfall: below 10mm/h Extensometer: below 1mm/h	Regular, Am 9:00 to Pm 16:00	One time per week
Attention	Rainfall: 10～20mm/h Extensometer: 1～2mm/h	Regular, Am 9:00 to Pm 16:00	One time each three days
Warning	Rainfall: 20～30mm/h accumulative: above 80 mm Extensometer: 2～4mm/h	Strengthening monitoring	24 hours
Evacuation	Rainfall: above 30mm/h accumulative: above 120 mm Extensometer: above 4mm/h	Evacuation	

Source: JICA Study Team

2.5.4 Data Collection and Analysis

Monitoring data of the subject slope, together with precipitation data, should be analyzed chronologically (See Figure 2.40).

Focusing points in data analysis are:

- To determine whether the monitored landslides are stable or unstable from the relationship between time and displacements
- To determine the effect of rainfall to the movement of a landslide from the relationships between displacement and precipitation
- To determine the level of warning or whether evacuation is necessary or not by referring to the standard values.
- To improve the standard values (Rainfalls and Displacements) by analyzing relationship between the displacement velocity and precipitation as well as visual observation results
- To forecast the time of occurrence of a landslide by measuring the displacement velocity. Generally, displacement velocity tends to suddenly increase immediately before the whole slide of a landslide mass so that the time of the landslide can be sometimes forecasted in advance by observing the increased velocity.

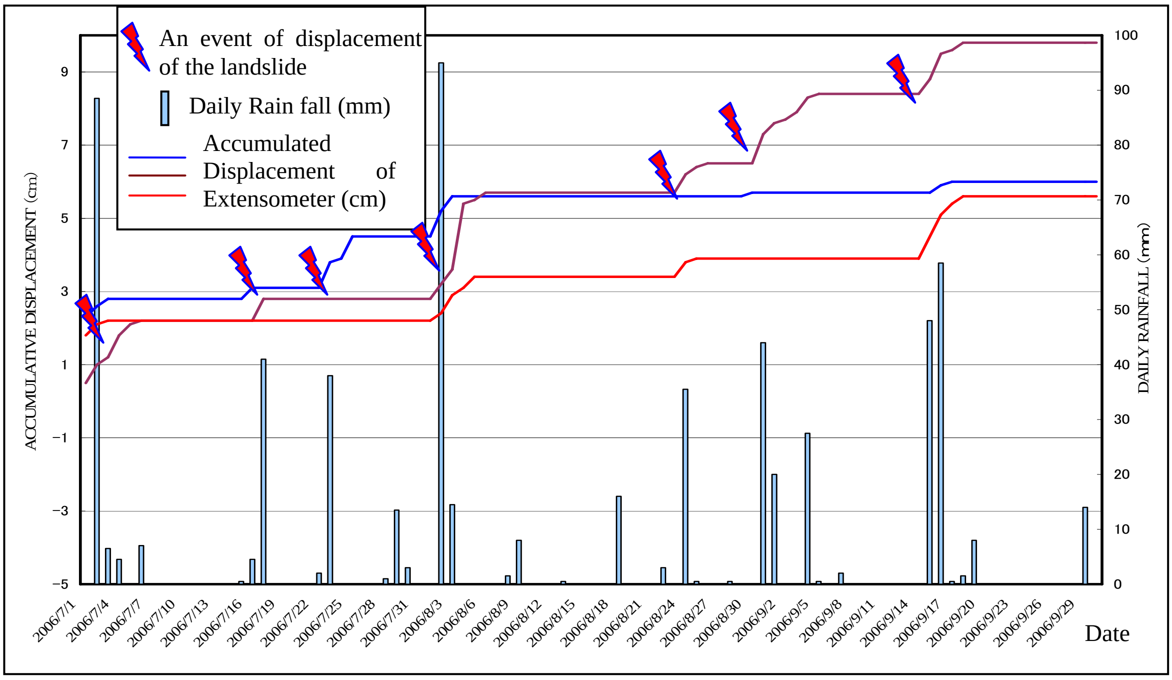


Figure 2.40 A Sample of the Stability Analysis of A Monitored Landslide Base on the Displacement Accumulation of Three Extensometers and Precipitation Data, (JICA Study Team)

2.5.5 Predictor of Landslide

(1) Murky Spring Water

Rapid increase or decrease of spring water indicates change of subsurface condition. Murky water might be caused by boiling or piping induced by heavy rainfall etc.

(2) Falling Pebbles

Pebbles falling are sometimes soon followed by a landslide. Strain accumulation reaching the limit of slope stability might cause the slope crisis. If traffic control is conducted immediately after the small rock falling, the risk of landslides can be reduced.

(3) Strange Sound

Strange big sound sometimes signals the outbreak of landslides.

At about 0:30 a.m., July 27, 2006 during a heavy rain, landslide and its associated debris flow occurred near the Minahaji Camp in Muzaffarabad City (See Figure 2.41). The resident heard unusual sound when the debris flow occurred, and could escape immediately before the residential building was destroyed.

Figure 2.41 A Residential Building damaged by a Debris Flow, about 600 m long. Debris Flow deposits are composed mainly of Limestone Gravels of 10 cm-20 cm in diameter, (Source: JICA Study Team)

(4) For a Long Moment after Heavy Rain

Some large scale landslides often occur after continuous or intermittent heavy rainfalls. Figure 4.42 shows image of assessment of slope stability based on rainfall. Accumulation of precipitation data and results of slope inspection would predict the occurrence of a landslide, although it is difficult right now.

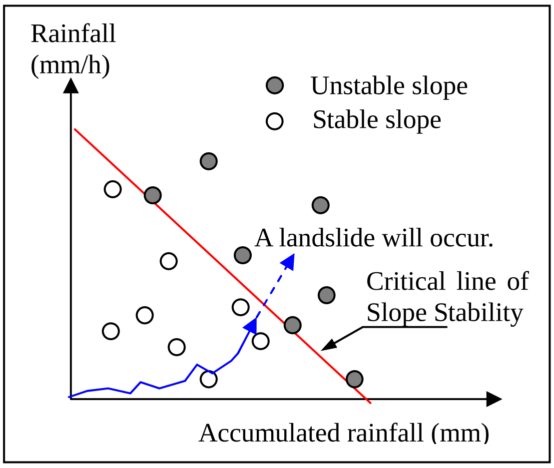


Figure 2.42 Image of Assessment of Slope Stability based on Rainfall (Source: JICA Study Team)

(5) Heavy Rainfall in Winter Season

In addition to general wet season from middle of July to September, relatively large precipitation is recorded from February to March as shown in Figure 2.43. Many landslides occur also during heavy rain fall of post wet season. Cold and wet condition will reduce amount of evaporation and accelerate saturation, which may cause a landslide.

In cold region freezing and subsequent melting sometimes causes rock falls. According to Japan experiences, a peak of rock fall occurrence records during 10-12 a.m.

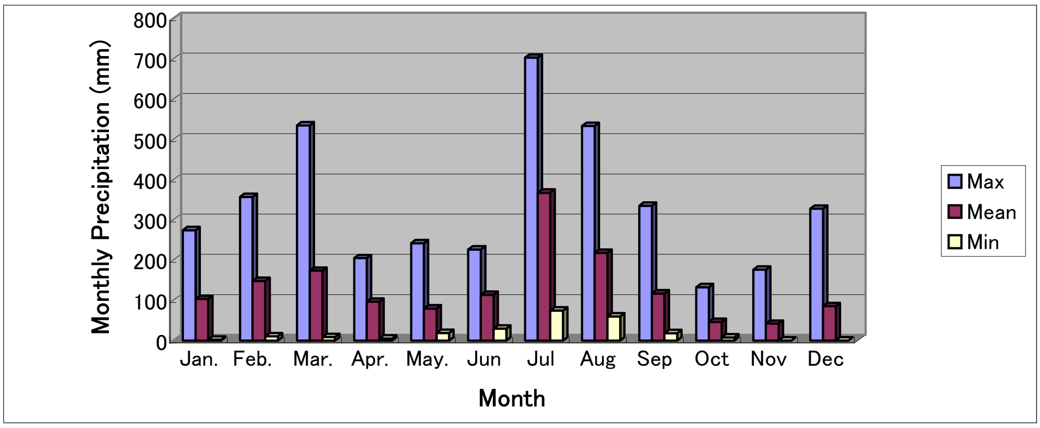


Figure 2.43 Monthly Precipitations (1985-2006) in Muzaffarbad, (Source: Meteorological Department, Islamabad, Pakistan)

SLOPE INSPECTION SHEET

FORM A: GENERAL INFORMATION

General Information

Region/District Name/Site Name			
Road Name		Inspected by	______ *of* ______ *(organization)* *Date:* ______ *Signature* ______
Chainage	*Start* ______ *km* *End* ______ *km*	Checked by	______ *of* ______ *(organization)* *Date:* ______ *Signature* ______
Side of Road	*Right / Left*	Type of Slope	*Cut / Embankment / Natural*
Slope ID / Field ID		Potential Disaster Type (*See Table 1)	*Rock fall / Collapse / Rock mass Failure* *Landslide(Landcreep) / Debris flow /Embankment Failure*

Historical Disaster Record	DATE:	DESCRIPTION

Location Map (1:50,000)

SLOPE INSPECTION SHEET

FORM B: SKETCH & PHOTOGRAPH & RECOMMENDED MEASURES

Slope ID	Chainage : *Start* *km* *End* *km*	Side of Road: Hill / Valley	Date:

Scale:

SLOPE INSPECTION SHEET

FORM C: SLOPE FEATURE

Slope ID	Chainage : *Start* km *End* km	Side of Road: Hill / Valley	Date:

GEOMETRY (Landslide)	Length Height	m m	Dip	(degrees)	Estimated depth of Landslide	m	
GEOLOGY (Landslide)	Soil ( ) / Rock ( )						
VEGETATION	Trees / Shrubs / Grass / Structures / Others (Surface coverage: %)						
Spring / Water Seepage	Spring (Continuous / Intermittent) / Water seepage / Not seen						
TYPE OF LANDSLIDE (Refer to the attached Table 1 General Features and Characteristics of Landslide)	ROCKFALL	Expected falling rock size	m	Active / Medium / Nonactive	Potential of Hazard High / Medium / Low		
	COLLAPSE	Huge / Medium / Small		Active / Medium / Nonactive	Potential of Hazard High / Medium / Low		
	ROCK MASS FAILURE	Huge / Medium / Small		Active / Medium / Nonactive	Potential of Hazard High / Medium / Low		
	LANDCREEP	Huge / Medium / Small		Active / Medium / Nonactive	Potential of Hazard High / Medium / Low		
	DEBRIS FLOW	Huge / Medium / Small		Active / Medium / Nonactive	Potential of Hazard High / Medium / Low		
	EMBANKMENT FAILURE	Huge / Medium / Small		Active / Medium / Nonactive	Potential of Hazard High / Medium / Low		
	OTHERS ( )	Huge / Medium / Small		Active / Medium / Nonactive	Potential of Hazard High / Medium / Low		
	COMMENT:						
EXISTING SLOPE PROTECTION	Gabions H= m, L= m	Rock Bolts m^2					
	Masonry H= m, L= m	Netting m^2					
	Concrete wall H= m, L= m	Others ( ) m^2					
	Others( ) H= m, L= m	*COMMENT:*					
DRAINAGE	Roadside Drains	Good Condition / Needs Repair / Not Present / Others ( )					
	Cascade Drains	Good Condition / Needs Repair / Not Present / Others ( )					
	Berm Drains	Good Condition / Needs Repair / Not Present / Others ( )					
	Culvert Inlet	Good Condition / Needs Repair / Not Present / Others ( )					
	Culvert Outlet	Good Condition / Needs Repair / Not Present / Others ( )					
	Water Drain Pipe (Wall)	Good Condition / Needs Repair / Not Present / Others ( )					
	Others ( )	Good Condition / Needs Repair / Not Present / Others ( )					
	COMMENT:						
MONITORING, IF NECESSARY							

SLOPE INSPECTION SHEET

FORM D: Consequence/Risk Level

Slope ID	Chainage : *Start* *km* *End* *km*	Side of Road: Right / Left	Date:

1) Slope Hazard Assessment

Hazard level	Rock fall / Collapse / Rock mass failure / Landcreep	Debris flow	Embankment failure
High (A)	A large number of obvious deformations of slope (scarps, bulges, side cracks etc.) Visible movement (cracks, subsidence, upheaval, toe erosion etc.)	Frequent occurrence: Within every two years	Frequent occurrence distributing traffic operation Visible deformation (tension cracks, settlement etc.)
Medium (B)	Landslide topographic indications, but movement is invisible	Periodical occurrence: over five years	Periodical occurrence, but not serious for traffic operation Visible deformation
Low (C)	Suspicious feature of landslide, but no evidence of present deformation.	Rare, but there are traces of collapse in the source area.	No deformation

2) Consequence Assessment (Reference only)

Consequence level	Annual average daily traffic	Danger to public assets/building occupants	Construction period of temporary diversion	Length of alternative roads
High (a)	1,000 and over	High	More than 24 hours	More than 50 km
Medium (b)	500-1000	Medium	12 hours -24 hours	20 km - 50 km
Low (c)	Less than 500	Low	Less than 12 hours	Less than 20 km

Note: Assessment items and their standard values are subject to change due to actual site conditions and social needs etc.

3) Risk Level Assessment

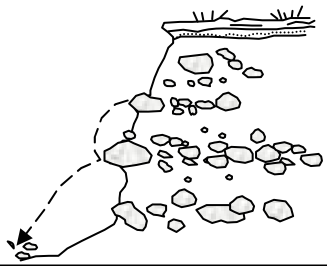
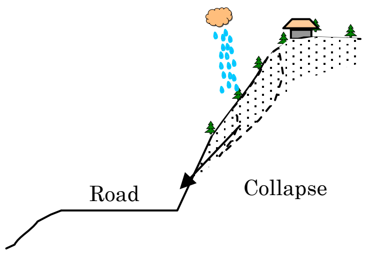
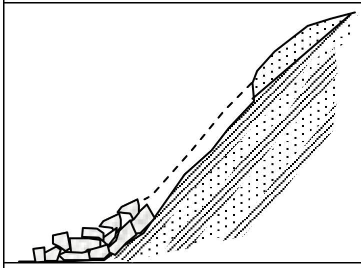
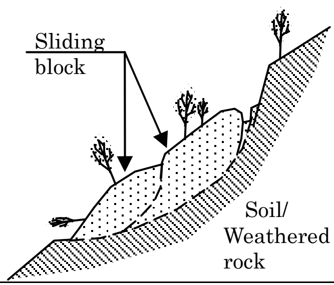
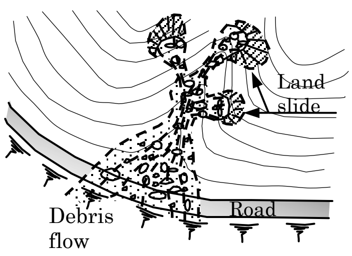
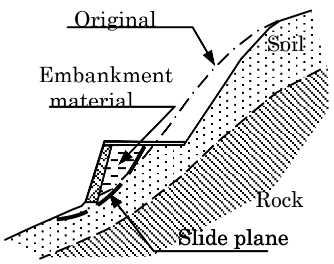
Risk Level	Combination*	Recommendable Action
I	Aa	Top priority for implementation of countermeasures
II	Ab, Ba	Implementation of countermeasures
III	Ac, Bb, Ca	Monitoring (monitoring displacement by devices/regular inspection)
IV	Bc, Cb	Bi-annual Inspection (before and after monsoon season)
V	Cc	No action

Note: Combination*
Hazard level A: High, B: Medium, C: Low; Consequence level: a: High, b: Medium, c: Low

4) Recommended Countermeasure

Countermeasure	Amount	Remarks

Table1 General Features and Characteristics of Landslide

Schematic Illustration	Description
	**Rock fall** Free fall or rolling down of a stone or an individual rock from a steep slope. Less than 5 m^3 in general.
	**Collapse** Collapsing materials are residual soil and highly weathered or jointed rocks. Prone to occur on steep slopes Triggered mainly by rainfall infiltration Less than 1000 m^3 in general
	**Rock mass failure** Rock mass failures on a rock slope are divided into slide, toppling, and buckling based on the direction of the failure, and furthermore the slide is subdivided into a planar slide on one separation plane and a wedge slide by a combination of separation planes. The failure volume is variable.
	**Landslide (Land creep)** A large scale and slow slipping mass-sliding movement of highly weathered rocks, debris and soil. Generally the failure volume is more than 5,000 m^3.
	**Debris flow** Landslides during/after heavy rainfall or a dam break upstream of the road slope induce an avalanche of rocks and earth. Generally it flows down with the gradient of over 20 degrees and starts deposition with the gradient of less than 10 degrees. The failure volume of debris flow is variable.
	**Embankment failure** All kind of failures concerning road embankment. The volume of embankment failure is variable. River bank erosion often induces a large scale embankment failure. Other major causes of embankment failure are insufficient loading of embankment materials, functional failure of drainages and a gully erosion of slope.

APPENDIX - A

A-2: Agendas of the Seminar

THE SEMINAR on SLOPE DISASTER MANAGEMENT
26th December, 2006

Programme of the Seminar

Registration

9:00 - 9:20	Registration

Inaugural Session

9:20 - 9:25	Recitation from the Holy Quran
9:25 - 9:30	Welcome Address and Introduction of Seminar by *Mr. Takao Kaibara, Resident Representative, JICA Pakistan Office*
9:30 - 9:40	Speech by the Chief Guest by *Mr.Sardar Attiq Ahmed Khan, Prime Minister, AJK Government*
9:40 - 9:50	**Keynote Speech** Engineering-geological evaluation of the candidate sites for new satellite towns of Muzaffarabad by *Prof. M. Chigira, Kyoto Univ.,(Mr. S. Sadiq & Mr. N. A. Khan, GSP)*

Tea / Coffee (10:10 – 10:30)

Technical Session I Slope Hazard and Slope Disaster Management *Chaired by Mr. Muhammad Abbas ,Additional Secretary, Ministry of Communications*

10:10 - 10:40	**Presentation 1** Fault surface rupture and geology of 8th October 2005 Kashmir Earthquake, Pakistan by *Dr. Allah Bakhsh Kausar, Director, GSP, Mr. A. Majid & Mr. H. Hussain, GSP*
	Speech by the Special Guest by *Mr. Muhammad Shamim Siddiqui, Federal Minister for Communications*
10:40 - 11:20	**Presentation 2** Earthquake induced slope disasters along Jhelum valley, a geomorphological implication based on field and satellite images' analyses by *Prof. H. YAGI, Yamagata Univ. & Mr. S. S. Akhter, GSP*
11:20 - 11:40	**Presentation 3** Engineering-geological conditions of the landslides along the Jhelum valley by *Prof. M. Chigira, Kyoto Univ., Mr. M. N. Mughal & Mr. S. Karamt, GSP*
11:40 - 12:10	**Presentation 4** Road operation and road slope management by *Mr. S. Takahashi, JICA Expert*

Lunch (13:00 - 14:00)

Technical Session II Disaster Risk Reduction for Steady Recovery from the8th Oct. 2005 Earthquake Damage *Chaired by Mr. Bgr Sher Afghan Khan Niazi, Director General(M&E), ERRA*

14:00 - 14:20	**Presentation 5** Outline of Reconstruction Master Plan for Muzaffarabad City by *Mr. Zahid Amin, Chairman, Development Authority Muzaffarabad*
14:20 - 14:50	**Presentation 6** Slope protection and early warning system of Muzaffarabad City by *Mr. Y. Momose, JICA Study Team & Mr. M. Latif, GSP*
14:50 - 15:15	**Presentation 7** Mitigation measures against landslide disasters - cases of Japan and Nepal Himalaya- by *Prof. D.Higaki, Hirosaki Univ.*

Technical Session III Envisioning Safer Pakistan - Slope Disaster Risk Reduction *Chaired by Mr. Amanullah Khan Jadoon, Federal Minister for Petroleum & Natural Resources*

15:30 - 15:55	**Presentation 8** Engineering-geological condition of Hattian Dam and MZD-BKT by *Prof. K. Konagai, Tokyo Univ.*
15:55 - 16:20	**Presentation 9** Proposal for mitigation of landslide hazards and restoration of slopes by *Prof. H. Marui, Niigata Univ.*
16:20 - 16:40	Question and Answer Session
16:40 - 16:50	Closing Remarks by *Mr. Hiroyuki Kishino, Minister, Embassy of Japan*

Tea / Coffee (16:50 -)

Workshop
on
Monitoring, Prediction and Mitigation of Landslide Hazards

1st day on Monday, 28th January 2008 at the Auditorium of National Highway Authority, Islamabad

Programme

Registration

9:00 - 9:30	Registration

Inaugural Session

9:30 - 9:35	Recitation from the Holy Quran
9:35 - 9:40	**Welcome Address** by Dr. Imtaiz Ahmed, Chairman, NHA
9:40 - 9:50	**Opening Remarks** by Mr. Takao Kaibara, Resident Representative, JICA Pakistan Office
9:50 - 10:20	**Keynote Speech:** Role of geology for landslide hazard mitigation by Dr. M. Ogasawara, JICA Study Team

Tea / Coffee (10:20 - 10:50)

Technical Session Chaired by Mr. Shigeki Takahashi, NHA JICA Expert

10:50 - 11:20	**Presentation 1:** Paleoseismic Evidence of Surface Rupture of the 2005 Kashmir Earthquake in Pakistan by Mr. S.S. Akhtar, Dr. A.B. Kausar, and Mr. M. Latif, Geological Survey of Pakistan
11:20 - 11:50	**Presentation 2** Earthquake Induced Geo-hazards in Kashmir and NWFP by Mr. S. Sadiq, Dr. A. B. Kausar, Mr. H. Hussain and Mr. A. Alam, Geological Survey of Pakistan
11:50 - 12:10	Question and Answer Session
12:10 - 12:40	**Presentation 3** Slope inspection works – Introduction of "A guide of slope inspection for road maintenance" by Mr. Y. MOMOSE, JICA Study Team of Jhelum Valley Road
12:40 - 13:10	**Presentation 4** Road disaster management by Mr. Shahid, Exponent Engineering
13:10 - 13:40	Question and Answer Session
13:40 - 13:45	**Closing Remarks**

Lunch (13:45 - 14:15)

2nd day (Tuesday, 29th January 2008): Slope Inspection Training

Time schedule

9:00 - 9:15	**Registration at NHA Head Office**
9:15 - 10:15	Move to the Site (under arrangements of NHA)
10:15 - 11:00	**Slope Inspection at Site 1**
11:00 - 11:15	Visit Site 2
11:15 - 12:00	**Slope Inspection at Site 2**
12:00 - 12:15	Visit Site 3
12:15 - 13:00	**Slope Inspection at Site 3**
13:15 - 13:30	Visit Site 4 (Inspection of an urgent measures installed slope)
13:30 - 14:00	**Lunch/Prayer break**
14:00 - 14:30	**Closing Ceremony**
14:30 - 16:00	Move back to NHA Head Office