3.4 Method for the Evaluation of Stability: Rock Collapsing

3.4.1 General

(1) Evaluation of Factor, Measures

It should be inspected for Rock Collapsing, which cover natural slope and cut slope and height is more than 7meters.

The types of rock collapse are nominated as rock falling, overturning and sliding of rocks and so forth (Figure 3.4.2). The factors for these phenomena depend on condition of cracks, the quality of rocks, topography and ground waters and so forth. The evaluation should be carried out with a focus on these factors and the degree of efficiency of existing countermeasure works. For the point of evaluation and inspection, a symptom of rock collapsing should be an important factor. However, it is not limited for the evaluation of stabilities at the spots. Because it is the insufficiency of data regarding rock collapsing, and it are not limited as low stability at the spots where the disaster such as rock collapsing have occurred before and so forth.

Evaluation of factors → Evaluation of countermeasures → Evaluation grade

Figure 3.4.1 Concept of Stability Evaluation Rating (Rock Collapsing)

(2) Integral Evaluation

The engineer considers the scale and the influence of natural disasters from following items;

- i) Disasters factors,
- ii) Effective of the countermeasures,
- iii) Conditions around the site.

After consideration the engineer make a policy of correspondence among the three as follows;

● It is necessary to take measures	There is a potential of disasters on the spots.
● To correspond with a table of the "Disasters Prevention Description Sheets"	There is a need to take measures in the future. But at the moment, control is exercised through vigilance as per the "Disasters Prevention Description Sheets".
● It is not necessary to take new measures	The site shows no disaster factors and there is no need to take new measures.

Table 3.4.1 Evaluation Criteria

Integral evaluation	Evaluation criterion
It is necessary to take measures	It is necessary to take measures, because the symptom of natural disasters is confirmed such as clear open crack and so forth.
To correspond with a table of the "Disasters Prevention Description Sheets"	A) A detailed survey is required Potential of factors for natural disaster , such as open cracks, are not so clearly, but the appears of spot are not stable. B) Prioritized observations shall be done with routine inspections At present, There is no disaster a factor according to the observation. However, it may be existing potential for the natural disaster on account of factor of because of topographical and geological reasons. It should be observed for abnormalities and deformation in the slope.
It is not necessary to take new measures	Disaster factors are not observed, and it is not necessary to take new measures.

(3) Factors to be considered for the Evaluation Score of Stability Survey

Factors to be considered during inspections of the rock collapsing are as follows;

1) Phenomenon, Symptom

a) Dimensions of an Open Crack

The symptom of rock collapsing has an intimate relationship with tension cracks (vertical direction). However, it is very difficult to distinguish characteristic of cracks between tension cracks and ordinary cracks. Especially, the change in the time series row is very difficult to understand.

Therefore, it is necessary to evaluate all type of cracks on account of consideration of safety side for the evaluation and inspection, particularly existing of open cracks and their scale.

Large open cracks have considered to potential tension cracks, Even though these deformations are not confirmed.

b) Direction of Continuous Horizontal Cracks

If the Continuous horizontal cracks, which have sandwich clay or crashed stone are observed, it shall be inspected. Those cases have the possibility of the displacement of mass rocks above the crack. Cracks those inclination has the same direction as the slope (slidable layer direction) should give much attention, because those cracks are related to sliding failures.

c) Small scale Rock Collapse or Rockfall

Small collapses or falls of rocks must be the subject of evaluation for Rock collapsing, because of the possibility that relate it. A deposit of sediments in the lower part of a slope, formed by previous small collapses or falls of rocks, should also be evaluated as symptoms of the rock collapsing. Moreover, if it has a history of small collapses, rock falls along the neighbor slopes with the same topographical and geological characteristics of the main site under inspection, it should also be evaluated as symptoms of disasters, because it may be possible to consider that there are disaster factors at the inspection site as well.

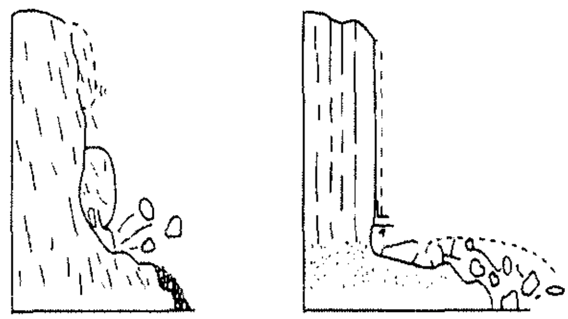
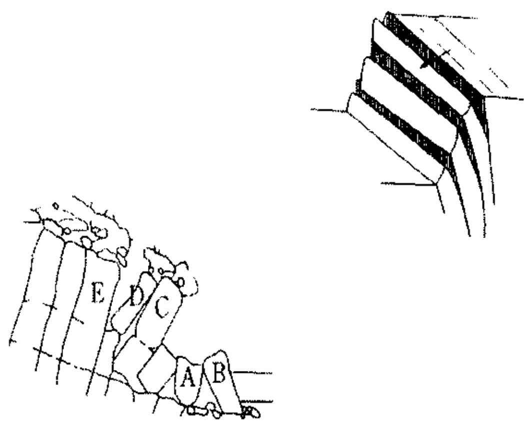
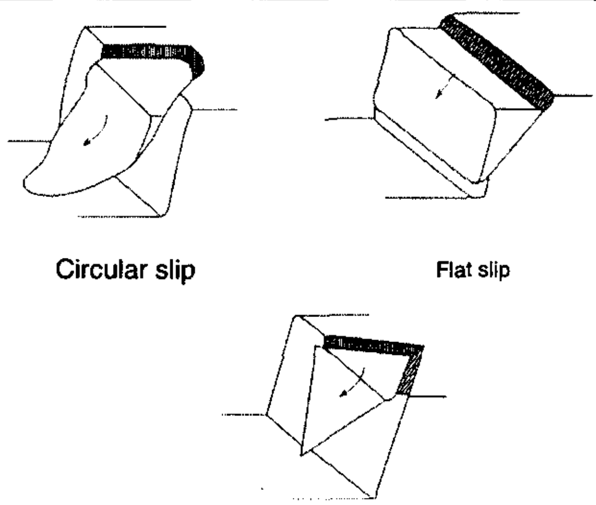
Types of Rock Collapsing	Description
Fall of earth his is the phenomenon that mass rock fall from the rock base at the discontinuities part such as joint of steep slope or cliff. It is the kinetic movements due to the rockfalls, as free fall, bound and jumps	
Overturning(toppling failure) It is the kinetic movement due to overturning moment. Overturning is made by gravity, the pressure from contiguous blocks, and water pressure along cracks.	
Rock slides It is the kinetic of shear slide such as the movement along circular slip surface or flat slip. Wedge-type failures are also a type of rockslide, which appear upper position above the surface along discontinuities part, and it are typical phenomena on pure rock slopes.	

Figure 3.4.2 Type of Rock Collapsing

2) Condition of Cracks (Joints)

The quality of rocks and the status of discontinuous areas, such as stratification planes, joints and fissures (hereinafter it are refereed as "cracks") shall be inspected.

Mass hard rocks seem stable. However, there are possibility of large scale collapse of rocks, if it has cracks with regular intervals around large area.

When soft rocks have cracks at irregular intervals, there is the possibility of a small-scale rock collapsing, because rock mass become small pieces.

3) Combination of Soft and Hard Rocks

It should be inspected for the combinations of soft and hard rocks which are thought to be related for the scale of the rock collapsing of objective spots.

It is necessary to make the attention for the combinations, which have hard rocks above soft rocks, because it tent to be made overhang shape and cause rock collapsing.

It is not so dangers that slope consist of hard rocks, because the magnitude of rock collapsing is small scale, even if the overhang is formed and cause collapsing (please see Figure 3.4.3).

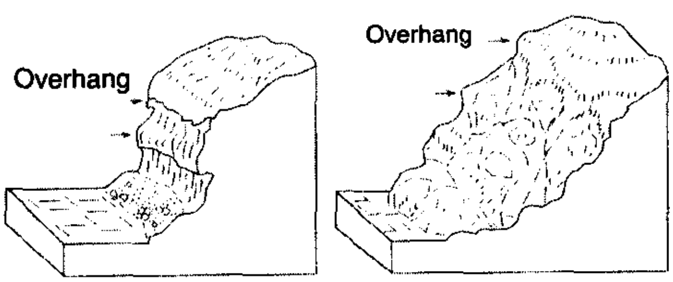


Figure 3.4.3 Overhang

4) Direction of the Sliding Layer, Direction of Stable Layers

When cracks have the same inclination as the slope direction, it seems sliding layer. In particular, it is necessary observe steep inclinations very carefully, because they have a large relevance for rock collapsing.

5) Topography

a) Slope and/or Cliff inclination

When the inclination of the cut slope and/or natural slope is steep especially overhang, it shall be inspected carefully, because those case has a high possibility of the rock collapsing. It is impossible to expect the buffering for impact of energy by rock collapsing in such case.

b) Slope Height

In general, higher slope have greater probabilities for the rock collapsing, and it shall occur with high energy. This is the reason why it is considered low stability case.

c) Shape of Slope

The relationship between the shape of slope and the rock collapsing should be evaluated for the stability with the following characteristics (Figure 3.4.4).

Ridge slope should be paid attention for the loosening of terrain, because it is nothing to hold by soil or materials in any side of the ridge.

It is necessary to observe slopes with talus which deposit weathered materials, since it repeated collapses and falls of rocks which may have taken place in the past.

Intermediate-type slopes between ridges and valleys should be considered to have rather stable than other types, because their progress of weathering are small.

Valley-type slopes, deposit colluvial soils and rock masses are found around the bottom of the valley only, and the possibility of a rock collapsing is generally low. However, it shall be paid attention in the case in which progress of weatheing of the rock masses is observed around the head of the valley.

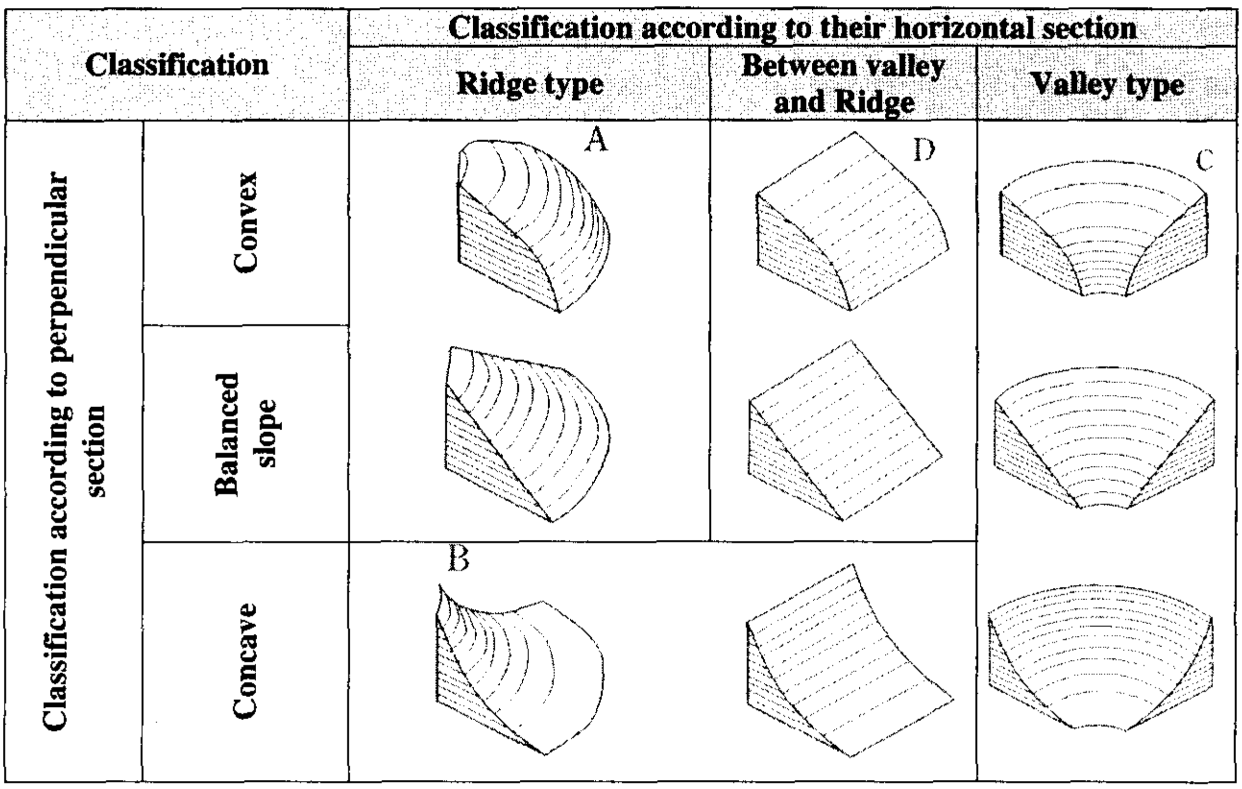


Figure 3.4.4 Classification of Types of Slopes

d) Knick Line

Knick lines are lines where inclination changes steep from slight, and it seems the shoulders of slopes (Figure 3.4.5). As knick lines are considered to bear relationship with the fall and collapse of masses of rock, slopes having such line should be inspected. It is considered that weathering and erosion formed steep slope in the bottom of the area. In this sense, the slope, which has the knick line from the foot, is the most weathered position and having erosion, and the appearance of the knick line clearly indicates the slope under stronger erosion.

Tension cracks are symptom of rock collapsing, and appear around the knick line.

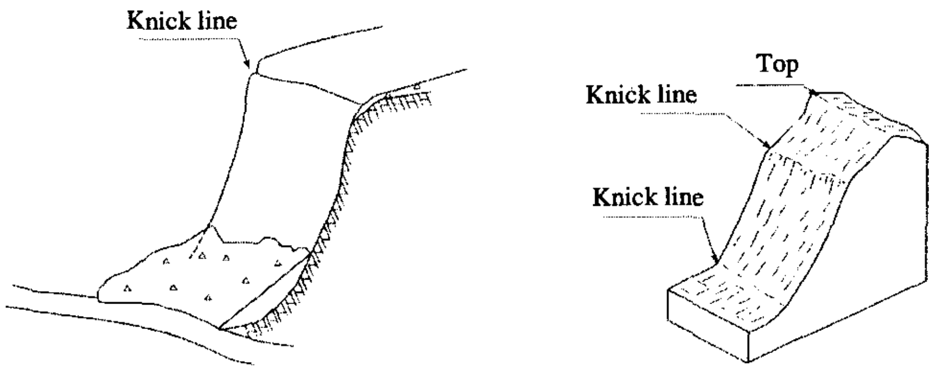


Figure 3.4.5 Definition and Example of a Knick Line

6) Ground Water, Rainfall

Rain is important factor of weathering. It should be paid attention in areas where there are springs along vertical cracks or in the border of horizontal cracks, because it is the possibility of the extension for spaces of cracks, and the cracks themselves.

3.4.2 Stability Inspection Table and Guidelines

Table 3.4.3 shows the Stability Inspection Table for the Rock collapsing. Guidelines to fill that table are shown as below.

(1) Evaluation of disaster's factors

1) Phenomenon, Symptom

a) Size of the Open Crack

The existence of open cracks in the slope should be verified at objective spot and it is effective to observe overview of the slope of rock masse. Above all, the check horizontal and diagonal cracks should be observed.

Even if slopes has no large open crack, it is necessary to observe detail of slopes where it has the joint and bending plane, and climbing to the top of the slope to confirm whether there are cracks near the shoulder.

<Evaluation Criteria>

The classification should be made in three categories, as i) Large, ii) Small, and iii) Not exist, according to the existence and size of the open crack.

i) The definition of "large open crack" is as follows. Figure 3.4.6 shows photographs as examples of large open cracks. The entire photo indicates large open cracks case.

It is the case:

[In the Head of a Displaced Mass Rock]

[1] To see the deepest part of the crack,

[2] The crack is clearly separated,

[3] The continuous crack is long, though the width is small,

[4] To see the difference level like step,

[5] The crack is not considered as open one, but there is continuous difference like steps and it is with the concave shape.

[In a side of the Displaced Mass Rock]

[1] Cracks are not continuous, but they exist side by side.

[In the extreme of the Displaced Mass Rock]

[1] There is an expansion along the weak and open position of the mass rock.

ii) The definition of "small open crack" is as follows:

[1] Open cracks are visible in the surface only,

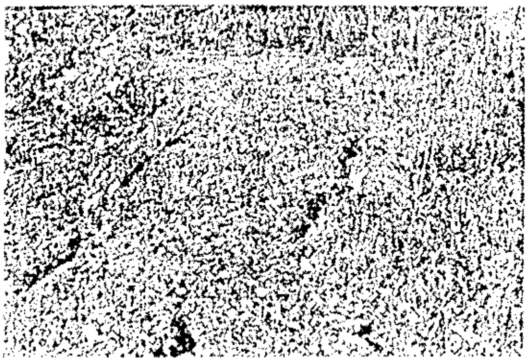
[2] The width of the open crack is very small, and there is no continuity. It is impossible to consider that the cracks are separated.

[3] There is no open crack, but many fissures, and it has already fractured.

Note: It is necessary to evaluate the cracks, such as the case that a vertical cracks appear in the overhang shape, with the observation characteristics of continuity and separation of the crack.

iii) The definition of "Not exist" is as follows:

[1] No crack, it is not visible



Parallel and not continuous cracks

Open cracks in the steep and slight joint

Continuous open cracks below the overhang

Rock mass sliding or falling due to toppling

Rock mass bending due to toppling

Open cracks in grid joints

Figure 3.4.6 Examples of Open Cracks Classified as "Large"

b) Direction of the Inclination of the Horizontal Continuous Crack

The spot where it has fractured rocks and/or horizontal continuous cracks with clay should be inspected, since there is a possibility of displacement of the rock above the cracks.

<Evaluation Criteria>

i) Direction of slidable

The inclination of the crack is the same as the slope. There is a high relationship to the sliding failure.

ii) Stable direction

The inclination of the crack has a contrary direction to the slope. There is a high relationship with overturning failures.

iii) Not exist

There is no horizontal crack.

c) Small Collapse and Fall of Rocks

It should be observed whether there are fallen rocks, colluvial soils and masses of rock in the foot of the slope under inspection.

The record of previous collapses and the topography of the terrain formed by collapses shall also be considered. Furthermore, it is necessary to observe for the occurrence of rock falls, colluvial soils and rock masses in nearby slopes. If there were any vegetation, observations should be careful on account of the invisible of signs of collapses.

<Evaluation Criteria>

i) Exists

[1] The existences of small collapse, both past one and present one (both of sliding signs and deposits of slid soils are confirmed).

[2] The existence of fallen rocks on the road or rock sheds position.

[3] The origin of fallen rocks is unknown, but there are gravel deposits around the foot of the slope (That's diameter is larger than 2 cm).

[4] There is an accumulation of gravel inside of the protection grid

[5] The slope is irregular (there is the possibility of signs of failure)

[6] There is a disaster record or history of collapses for nearby slopes.

ii) Not exist

[1] Small collapses or fallen rocks are not observed.

[2] Materials deposited at the foot of the slope are sand and pieces of rock (that's diameters is less than 2 cm).

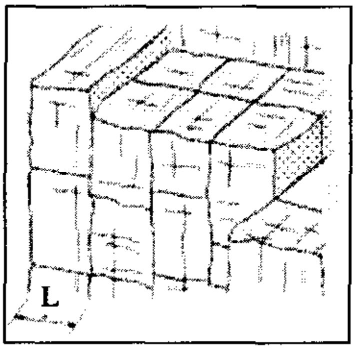
(If the deposited material which fallen from the knick line is surfaced, or granite, weathered sandstone and sand, cover slope, it should be considered to be the normal scale rockfalling.)

[3] There is no record and/or history of collapses, rock falls, or signs of either one.

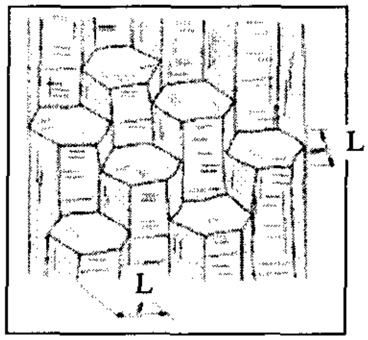
Note: When the surface of the slope is covered with shotcret and it has not cracks in the surface, the classification shall be "Not exist". If cracks are observed on slope, the classification should be "Exists".)

2) Condition of Cracks

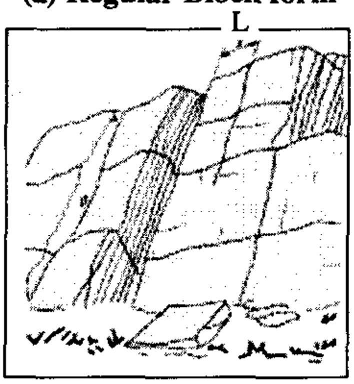
The quality of rocks and the frequency of appearance of cracks should be inspected. The inspection should be done more carefully because of the most important factors. Figure 3.4.7 shows examples of regular and irregular cracks.



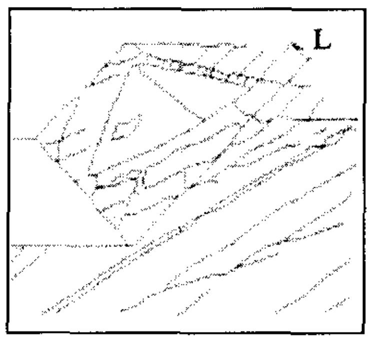
(a) Regular Block form



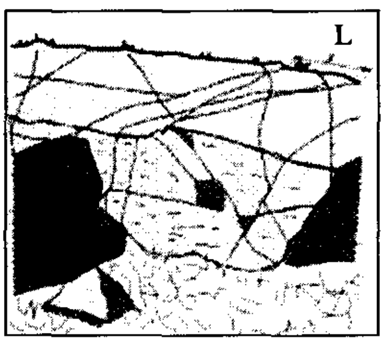
(b) Regular Column Form



(c) Laminar Form



(d) Wedge Form



(e) Irregular

L: Interval of the crack

Figure 3.4.7 Regular (a, b, c, d) and Irregular (e) Cracks

<Evaluation Criteria>

a) Rock Quality

Rock quality should be classified into two categories:

i) Hard rock: If it is beaten with a hammer, there is a rebound with Metallic sound.

ii) Soft rock: If it is beaten with a hammer, layer is peeled off apart with dull sound.

b) The Frequency of the Appearance of Cracks

i) Regular type with an interval larger than one (1) meter

Outstanding cracks occur regularly, and the interval of cracks is larger than one meter.

ii) Regular, with an interval smaller than one (1) meter

iii) Irregular

Cracks occur irregularly.

iv) Not exist

There are no continuous cracks. There is no science back borne. When there are several species of rock, all of them have similar resistance.

Note: the cracks addressed here means the character from the beginning of stratification and joint. Fault, which do not contain open cracks as the result of rock mass deformations and fractured zone are also evaluated Claus 2). If there were any difficulty in distinguishing one from another, the crack will be considered an open crack, and evaluated as in a) in Clause 1).

3) Combination of Lithofacies

Combinations of hard and soft parts should be inspected. The criterion to distinguish one from the other is as follows;

Hard part: If it is beaten with a hammer, there is a rebound with Metallic sound.

Soft part: The vulnerable part of exfoliation, no joint form, abnormality and development of irregular joints, etc., it became vulnerable condition due to sandwiched soft rock and it is broken with the hammer blow. Soil is included in the "soft part".

<Evaluation Criteria>

i) The upper part is hard, and the lower part is soft.

The example of a slope whose upper part is hard and a lower part is soft is shown on Figure 3.4.8.

ii) The upper part is soft, while the lower part is hard.

iii) The entire slope is made of soft materials.

iv) The entire slope is made of hard materials.

There are no vulnerable layers; the slope is formed of homogeneous hard rock.

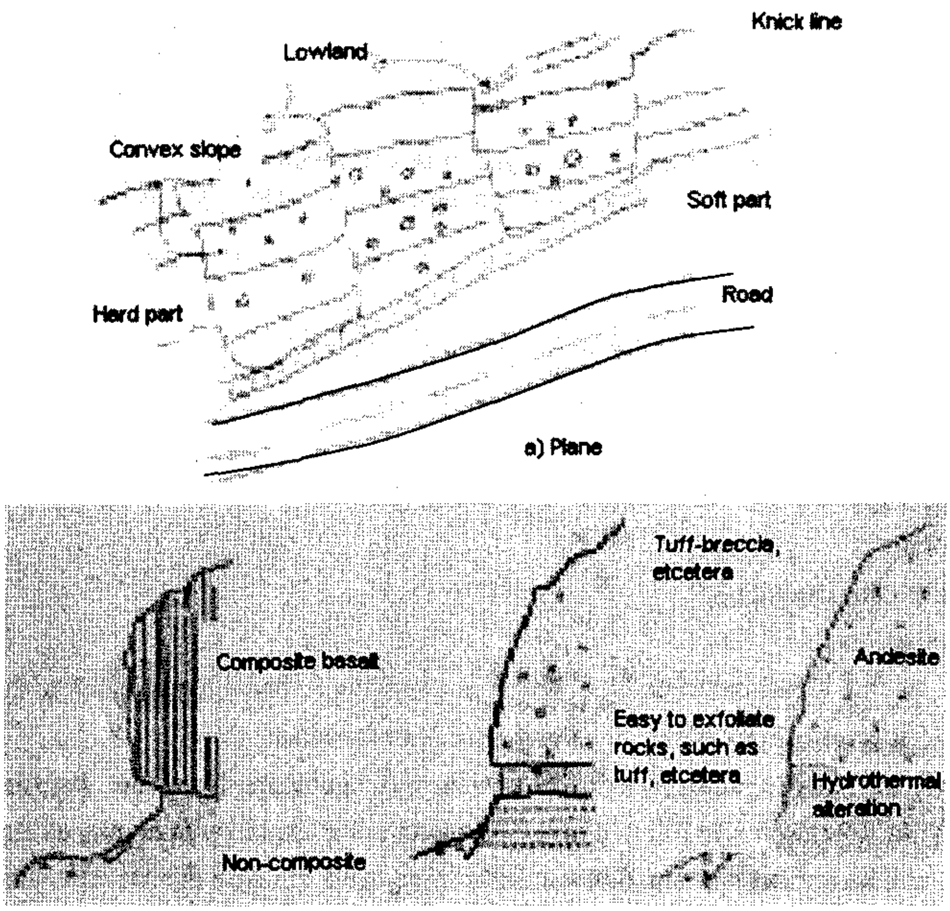


Figure 3.4.8Example of a Slope (Upper part is hard materials and lower part is soft Materials)

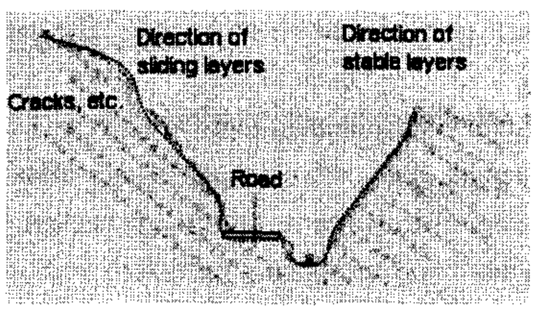


Figure 3.4.9 Direction of Sliding and Stable Layers

4) Direction of Sliding Layers and Stable Layers

Discontinuity areas, such as stratification areas, joint, cracks and fissures, should be confirmed for inspection, and the inclination, which has most steep angles, is also measured.. The following conditions must be borne in mind:

i) If there are several continuous discontinuity areas, it should be chosen the one which cover most of slope.

ii) An inspection should be done of the road site where the discontinuity area connects to the slope.

iii) In case of the discontinuity area is not clear, it should be substituted by the general inclination of the slope located around site.

iv) Discontinuity areas and open cracks on knick line are addressed in a) in 1) in (1) of Sub-Clause 3.4.2, on the above. The "Direction of sliding layers" and "Direction of stable layers" are shown on Figure 3.4.9

<Evaluation Criteria>

i) Direction of sliding layers: the inclination of the discontinuity area coincides with the inclination of the slope

ii) Direction of stable layers: the inclination of discontinuity areas runs contrary to the inclination of the slope

iii) Not exist: There are no discontinuity areas, or the discontinuity area is horizontal direction.

5) Topography

a) Cut slope and/or Natural Slope Inclination

The mean inclination from the road or the foot of the slope up to the knick line of the slope should be measured. It is shown on Figure 3.4.10 a), measurement of angle α of slope A. Slope B, with a slight inclination, is generally the slope, which consists of the soil. Therefore, angle β is not measured because of priority.

<Evaluation Criteria>

The criterion to determine the concept of "steep inclination" is 60°, and that inclination should be used to classify slopes. If an overhang with a greater than 1m depth exists in a slope, this is considered to be lower stability than a steep slope case.

i) Overhang

ii) Angle more than 60° degree.

iii) Angle less than 60° degree.

b) Height of a Slope

The height from the road or the foot of the slope up to the knick line of the slope should be measured. In the case in Figure 3.4.10b), the height of the slope is H1. However, the width D of the slope B, is the same or smaller than the road width W, the height should be considered as H1 + H2.

When the knick line is not clear, i.e., the inclination changes slightly or the position near the ridgeline, the height of the slope must be measured up to the ridgeline.

<Evaluation Criteria>

Slope height is classified into four categories:

i) More than 100 meters
ii) From 50 to 100 meters
iii) From 30 to 50 meters
iv) Less than 30 meters

c) Slope Type

Objective slopes should be classified into four categories, as shown on Figure 3.4.4

<Evaluation Criteria>

i) A: Ridge type
ii) B: Slope with deposits of weathered materials
iii) C: Valley type
iv) D: Intermediate type, between ridge and valley

The slopes which is unclear to be applied category should be classified as D.

d) Knick Line

It should be made overview spot where it can see the entire slope. The evaluation should be made also through aerial photographs and topographical maps.

<Evaluation Criteria>

i) Clear; there is a clear point where the inclination changes (without degree of inclination)
ii) Intermediate, between "clear" and "unclear"; there are several knick lines, but no drastic changes in inclination, and it changes slightly.
iii) Unclear; there is no clear point where the slope changes. Slope inclination becomes slight very gradually.

6) Ground Water, Rain

a) Spring Water

The existence of spring waters may be supposed from meteorological data of the areas surrounding the inspection spot.

<Evaluation Criteria>

i) There is spring water all the time
  [1] There is a spring in the slope, or the water comes up (a stream of water)
  [2] The place where the ravine ends, and there is always a stream of water is not included.

ii) After rains, there is an inflow of water

[1] After rains, some sites remain wet condition, even though some other areas have already dried up.

[2] The place where the ravine ends is not included.

b) Sites where Inflow water occur

When inflow water is observed inside a vertical cracks or the boundary of a horizontal crack, there is a possibility of extensions of cracks and voids grow inside of the crack.

<Evaluation Criteria>

i) Space in vertical cracks

There is inflow water inside a cracks

ii) Boundary of horizontal cracks

There is inflow water around the boundary of horizontal cracks

iii) Not existence

There is no inflow water.

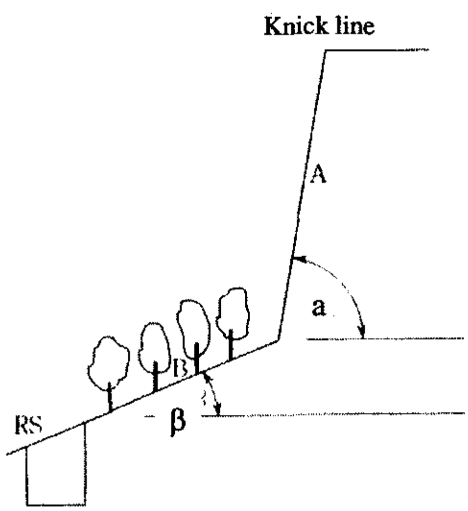


Figure 3.410 a)
Angle of the Inclination of a Slope

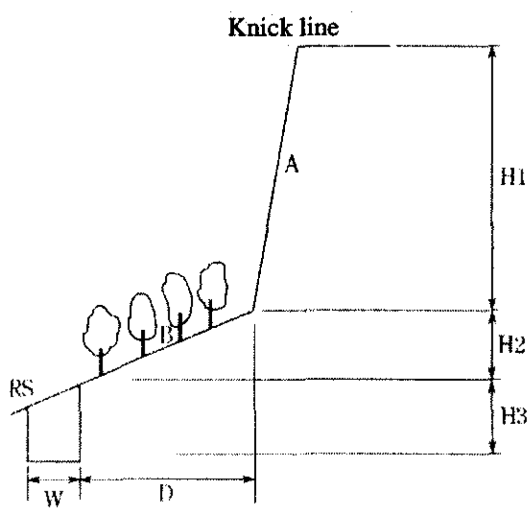


Figure 3.4.10b) Slope Height

3.4.3 Record by Inspection Site and Guidelines

A integral evaluation should be made by filling the "Stability Inspection Table", and also filling the "Record by Inspection Site" with photographs and drawings of the site.
Also, the reason for the integral evaluation should be stated, in the column of the registration table titled "Special Note".
In this case, the keywords given below should be used.
If the space given were not enough to enclose a location map and/or drawings, those sheets *are appended and filed together.*

<Keywords>

- Rock quality and species (Period, etcetera)
- Form and position of the crack
- Position of failure (fall, overturning, slip)
- Type of collapse
- Scale of the collapse (normal scale, maximum scale)
- Possibility of collapse (trigger factor, etc.,)
- Direction and process of collapse
- Extent of collapse (possibility of reaching the road area)
- Influence on traffic (importance of the road, traffic volume, etc.,)
- Reason for the integral evaluation.

Table 3.4.2 Record by Inspection Site

Format-3-1

No.		Inspection Item		Name of the road		Kilometer post (of)		(to)		From Managua / To			Total m.	
Clasification	Toll / Common	Category		Name of the site		Site mark		Latitude		Longitude				
Traffic Restriction	Yes (Crossing/Special) Not	Restriction Criteria		Traffic Volume	Day of the week		Holliday		DID	Yes No	Bus Route	Yes No	Detour	Yes Not

Pictures of the site, Sketch (to indicate the location of the existimg works and the site mark)	Location map (scale 1/50,000)

Special remarks: Inspection Date: / / (Weather: clear・cloudy・rain) Method of inspection: Note:	Disasters history	Yes (1. See damage record, 2. unknow details:) Not
	Other inspection objectives	Exist or Not Rock fall, collapse, rock mass collapse, land slide, debris flow, embakment, retention wall, bridge, others
	Inspection result of year	Score: (Completed・In execution・Not started) Countermeasure:
	Inspection result of 2002 year	Score: Integral evaluation: 1. It's necesary to take measures: 2. Response, making prescription of prevention: 3. It's not necesary to take measures:
	Forecast of disasters dimension	
	Proposal countermeasures	Kind of work: Norm: Quantity: Preliminary cost:
	Stability in case of seism (for rock fall & collapse only): stable / unestable	

Table 3.4.3 Stability Investigation Table

Stability Investigation Table (Rock Mass Collapse)

[Factor A]

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

Inspector's Name	
Organization	

Form 4-2

[Threatment Work] (B)=(A)+ α o (A)X0

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

[Total Evaluationl]

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

Table 3.4.4 Record of the History of Damages

Form - 5-1

No.		Type of disaster		Site	Kilometer post (of)	(to)		From Managua/ To	
Inspection Site Year	Respond / Not Respond				East longitude		North Latitude		

Plane (Damages, Measures)	Seccion (Damages, Measures)

Pictures, Sketch of actual situation	Remarks	
	Date of disasters	
	Dimension	Wide, Long, Depth (m) m, m, m
	Inciding factor	Precipitation: Continue mm/ hr·d Maximum m Earth quake: Magnitude
	Damages	Human damages: deads Injuries: Material damages: Total cost of damages loss: Comments:
	Traffic restriction record	1.Full restriction: hours 2. One way road restriction: hours. 3. Others:
	Countermeasure	Year of construction: Type of works: Approximate Cost:

3.5 Method for the Evaluation of Stability: Slopeslide

3.5.1 General

(1) Evaluation Factor, Measures and History

Slope slides have characterized for slow deformation and repetitions in general. Therefore, it is easy to observe deformation for typical terrain in these characteristics besides first slope slide. However, some area where it have formed by the eroded soil or covered with vegetation, are difficult for observation due to invisible of landslide phenomenon.
Terrains and potential for slope slide are not scattered at random, but concentrated in areas with certain typical topographical and geological factors.

As for stability survey, the typical topographical and geological factors of slope slides are evaluated firstly. Then, an evaluation is made of the history of slopeslides and the current symptoms of it. Finally, the score for stability should be compared and chosen the higher rating of the two previous evaluations, and add the revision with the efficiency for previous countermeasures.

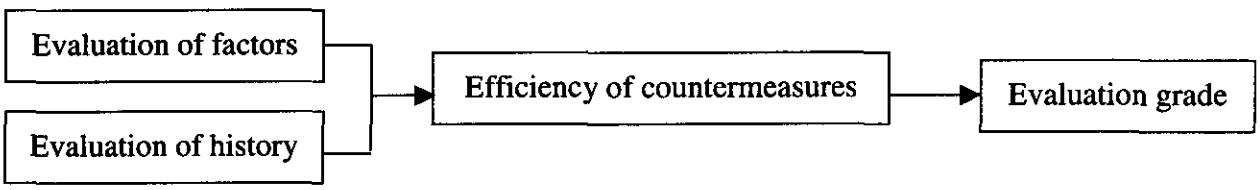


Figure 3.5.1 Concept of Stability Evaluation Rating

(2) Integral Evaluation

Engineer considers the scale and the influence of natural disasters from following items;

i) Disasters factors,
ii) Effective of the countermeasures,
iii) Disaster historys,
iv) Conditions around the site.

After consideration the engineer make a policy of correspondence among the three as follows;

● It is necessary to take measures	There is a potential of disasters on the spots.
● To correspond with a table of the "Disasters Prevention Description Sheets"	There is a need to take measures in the future. But at the moment, control is exercised through vigilance as per the "Disasters Prevention Description Sheets".
● It is not necessary to take new measures	The site shows no disaster factors and there is no need to take new measures.

Table 3.5.1 Evaluation Criteria

Integral evaluation	Evaluation criterion
It is necessary to take measures	Where a symptom of slope slides is confirmed.
To correspond with a table of the "Disasters Prevention Description Sheets"	Notorious symptom of slope slides is not confirmed, but there is a possibility of movement of slope.
It is not necessary to take new measures	Symptom of slope slides is not confirmed at all.

Note: Even if it is not necessary to take new measures, an inspection must be made two or three times a year.

(3) Factors to be considered for the Evaluation Score of Stability Survey

A slope slide is phenomenon, which a part of a natural slope moves to lower direction, because of loss the balance of slops due to heavy rains or increase of ground water levels. The possibility of such a displacement should be evaluated from the points of view of factors ("topographical factor for slope slide" and "geological factor for slope slide") and also history ("history of slope slide" and "symptoms of slope slides").

1) Typical Slope slide Area

Slope slides can be divided into two categories;

The first case is the area, which soil is displaced again along the slope, and the typical terrains are formed (repeated slope slides).

The second case is the area, which the displacement takes place for the first time, and the site does not show the typical appearance of slope slide areas. The first case shows a high frequency of generation of slope slides, while the second case shows a low frequency of it. Therefore, to identify a potential slope slide site, it is important to clear image of the characteristics of form and the terrains for slope slides.

2) Geology

Landslides has tendency to occur in the place where it is primarily in Tertiary deposit areas (e.g. Green tuff area), and in both fractured zone and volcanic alteration areas. It is important to understand the relation between the occurrence of slope slides and geological conditions. If geological characteristics can be recognized by means of aerial photographs, and topographical and geological maps, it is possible to identify potential slope slide sites beforehand.

3) History of Slope slides

Slope slides are periodical and repeated events. Therefore, an understanding of the history of slope slides in the area is very important to recognize the possibility of disasters in the future.

4) Slope slide Symptoms

When activities of slope slide begin, a micro-topographical symptom is formed in the soil, with cracks, subsidence and upheavals of the soil. These phenomena are the symptoms of the displacement of soils, and are an important key to know the situation of both types of slides in 1) in (3) in 3.5.1. Often, slope of new constructed road moves after few years due to cutting and embankment works. In these cases it is very difficult to make an evaluation of potential slope slide at sites before construction, therefore identifying symptoms, like abnormalities in the terrain and take a some countermeasures by the structure, are very important.

(4) Attention of Inspection

Since symptoms of slide are hardly notorious, it is necessary to inspect sites paying attention to changes in the terrain, such as cracks, subsidence and upheavals, etc. It is not only occurred but also other place, it should be paid attention and observed it very carefully from the upper and lower slope of the road. But, basically it should be observed from the road area as the observer's sight.

Terrains formed by landslides can be distinguished from other terrains through aerial photographs. In such case it is easy with aerial photographs facilitates to obtain information about micro-topography, vegetation, geology, etc. Using topographical maps to a scale of 1/25,000 it is possible to recognize the characteristics of the terrain through contour lines also. Moreover, it is effective for using telescope and taking a general view of the slope, to be achieved and understand the characteristics of the terrain.

(5) Area under the Influence of Slope slide Activities

The area under the influence of landslide activities (see figure 3.5.2) is estimated as follows:

i) Its length is twice as long as the block of the slope slide
ii) Its width is twice as wide as the block of the slope slide
iii) And its influence in the upper side is estimated from the head of the block of the slope slide.

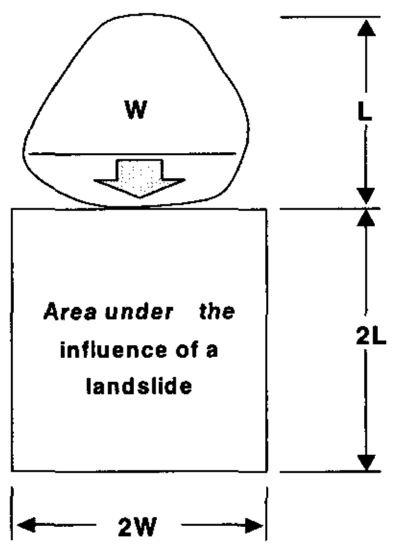


Figure 3.5.2 Area under the Influence of Slope slide

(6) Unit for the Inspection of the Body of Landslides

If two slope slide each other or one is over the other, all the bodies of slope slides should be the objective spot of inspections. In this case, the evaluation score and the integral evaluation will be chosen either that of the highest-rated.

3.5.2 Record to Stability Inspection Table and Guidelines

The "Stability Inspection Table" for landslides is shown as Table 3.5.3 The Guidelines for filling this table are located below the table.

(1) Evaluation of Factors

1) Terrain formed by slope slides

The characteristics of terrains formed by slope slides are given below i) –xii). It should be careful not to mistake a terrain formed by slope slides for a river terrace, a coastal terrace, a lava plateau, or a terrain formed with sediments from pyroclastic flows. The location, where rock masses crumble with tracts of slope sliding in its surrounding area, are very high potential for slope slide also. Slope slides also occur in relation with faults, and therefore attention must be paid to sites where located along a fault.

To fill the Table of Stability Sheet, it should consider for the factor whether clear or unclear, and, whenever there should be a difficulty in the definition, one should choose the high-grade evaluation (Unclear => A little clear => Clear). The "clear" concept is applied to situations when the block of a slope slide can be distinguished easily from other terrains.

- i) Deformation in contour lines. The distance between contour lines is reduced in the upper side, enlarged in the medium, and then it is reduced again in the lower side (Figures 3.5.3 – 3.5.7).
- ii) The upper side of a natural slope has the shape of either a horseshoe or a rectangle, while the medium region has a slight inclination (Figure 3.5.8). And there is a small isolated ridge (Figure 3.5.3, 3.5.7).
- iii) There are concave, subsided terrains or cracks. And there is a belt of subsidence in the slope and/or the summit.
- iv) A regular distribution of ponds, swamps and muddy lands.
- v) Side of a terrain is formed with galley or fissile (Figure 3.5.9).

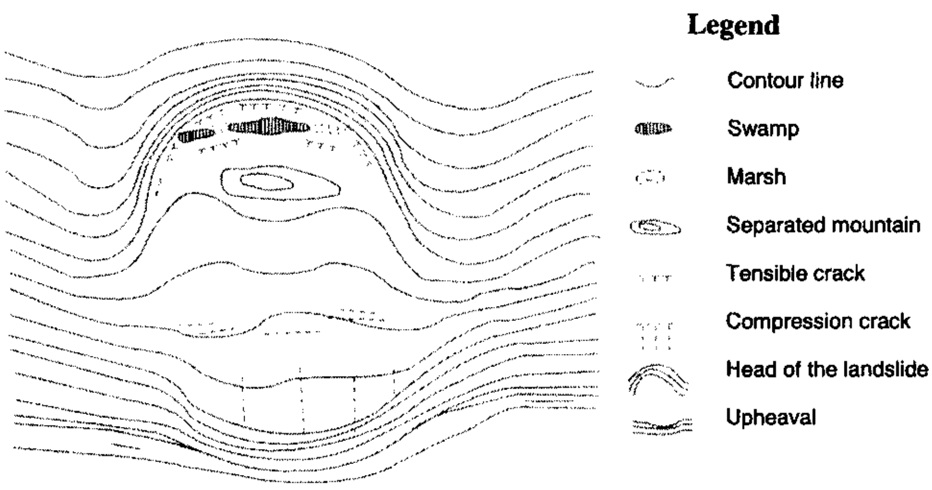


Figure 3.5.3 Model of a Terrain Formed by a Slope slide (Concave and Simple hill)

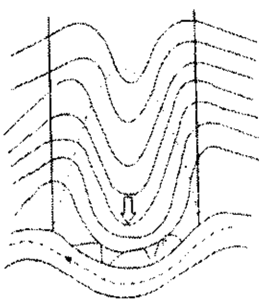


Figure 3.5.4 Convex Ridge

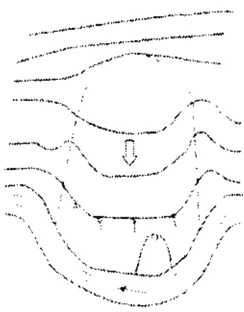


Figure 3.5.5 Convex Plateau

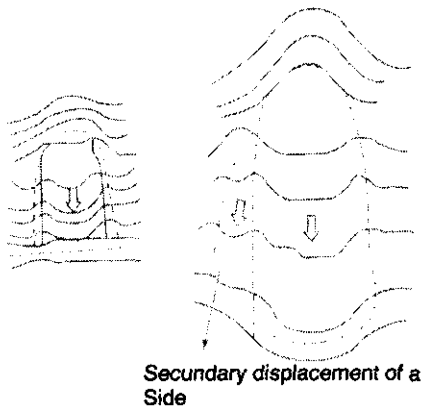


Figure 3.5.6 Concave Hill

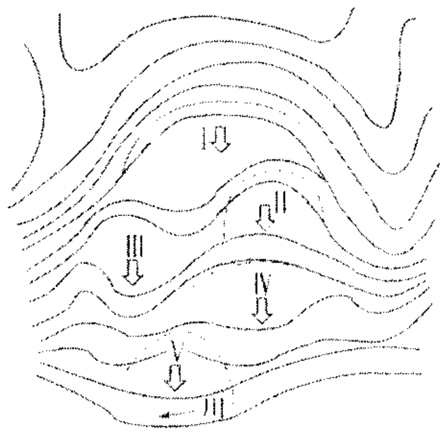


Figure 3.5.7 Several Types of Concave Hill

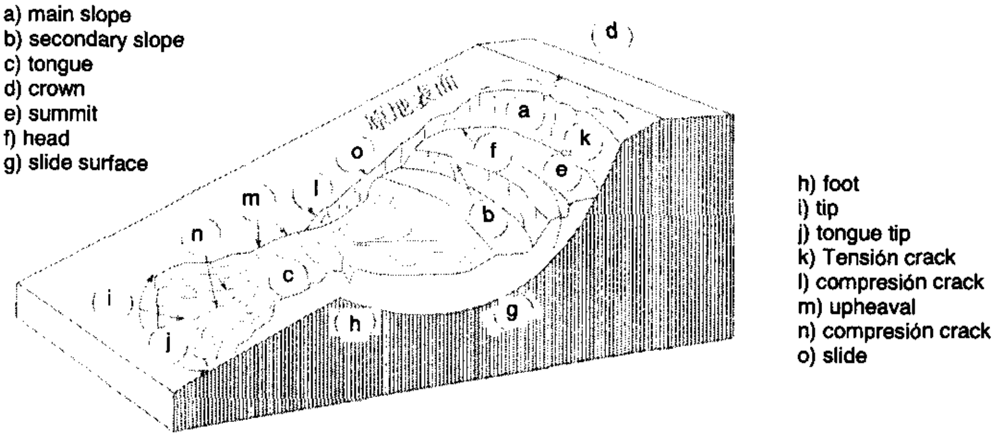


Figure 3.5.8 Names of Parts at Slidable Terrains

vi) Area behind slope slide is concave shape.

vii) Area where make a detour block where have water system, or Area where collect water due to dead end of river.

viii) Area where have shelf rice field.

ix) Areas where have upheavals or expansion in the foot of natural slopes.

x) Slopes where are attacked by water; or, the case where the area attacked by water consists of hard rock, those two sides belong to natural slopes (Figure 3.5.12).

xi) Where rivers bend, or where there is erosion (Figure 3.5.12).

xii) Where there is an extraordinary bending of a river, or where the river width becomes narrow.

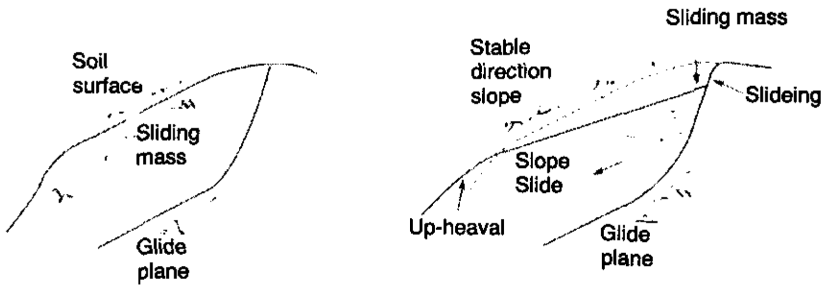


Figure 3.5.9 Variation of a Lateral Crack

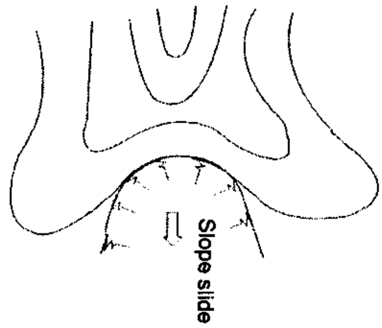


Figure 3.5.10 Ridge behind the Slidable Terrain

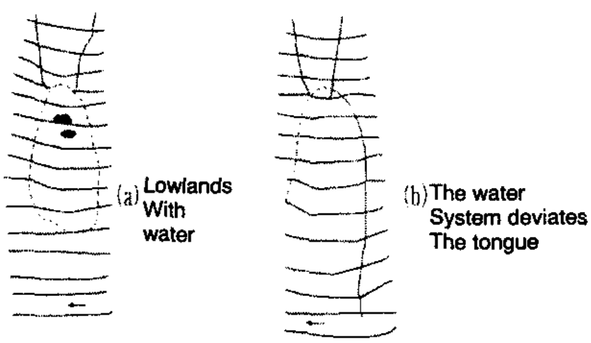


Figure 3.5.11 Easily Sliding Terrain

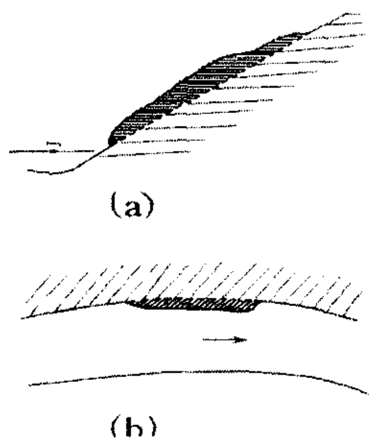


Figure 3.5.12 Unstable Natural Slope

2) Geology

a) Geological Structure

To evaluate the factors for a slope slide, the following items should be confirmed on the slope and/or natural slope under inspection.

i) Fault, fractured zone

The general relationship between a fault or a fractured zone and the slope slide area is shown on Figure 3.5.13. The words "fault" and "fractured n zone" used here mean direct relationship with a slope slide. These relationships between a fault or fractured zone and the occurrence of a slope slide is listed below:

[1] Part of the fault area becomes the slope slide or main scrap which regulate the slide zone.

[2] The fault or fractured zone become a channel for groundwater, or they becomes a barrier for wateflow, and a lope slide shall be made due to the domination of the stream of water by them.

ii) Volcanic alteration zone, solfataric soil

In volcanic zones, hot thermal waters produce the chemical transformation of rocks.

An alteration of the quality of rocks in function by thermal water is called volcanic alteration. Rocks affected by volcanic alterations become solfataric soils. Where there is such an influence, there is a potential for a slope slide.

iii) Layer located in a slide direction

Natural slopes with layers located in a slide direction have a potential for slope slide, and, above all, they have a high potential for rock slip type or fluid type (Figure 3.5.13, Figure 3.5.14). Some layers located in a slide direction have two type which are indicated in Figure 3.5.17. First, inclination is steeper than the natural slope as type (a), others have a slight inclination as type (b). The potential of (b) for a slope slide is greater than type (a), but type (a)case should be make attention for the crack in the top side.

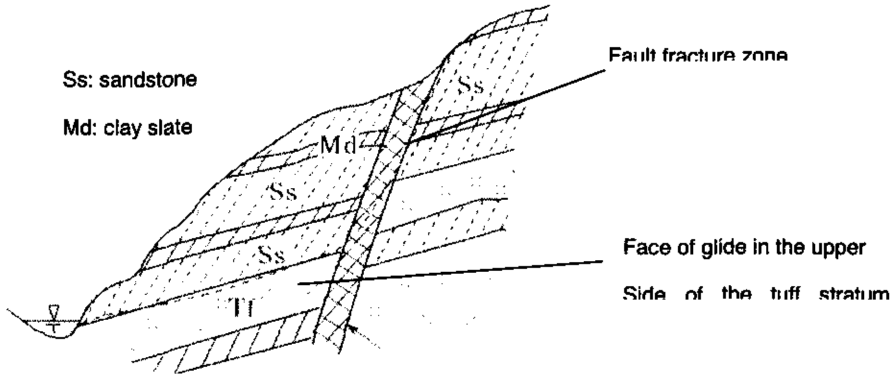


Figure 3.5.13 Model of the Sliding of Rock Masses due to the Inclination of the Slide Direction and a Fault

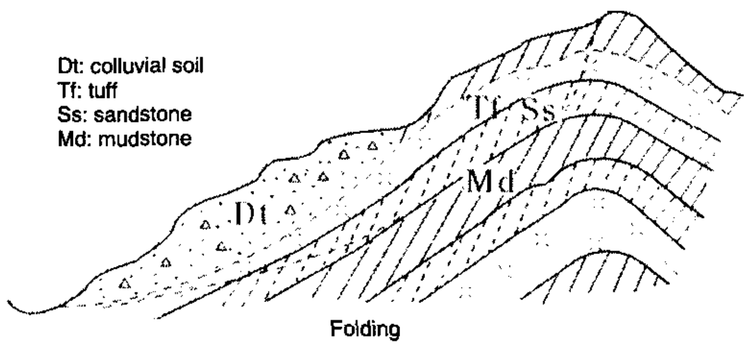


Figure 3.5.14 Model of the Slide of Rock Masses and Colluviums Soils due to folding(anticline structure)

iv) Layer with an stable direction

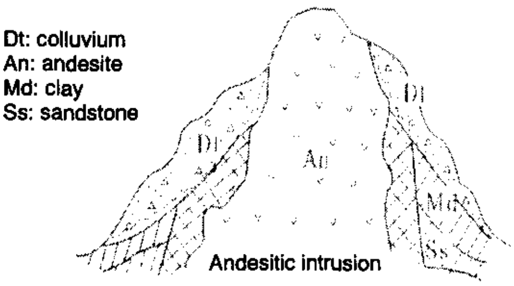
In natural slopes with stable direction layers, have a potential for small or medium magnitude scale slope slides (Figure 3.5.17).

v) Intrusive rock structure

There is a potential for slope slides in colluvial soils zone where are located around intrusive volcanic rocks (Figure 3.5.15).

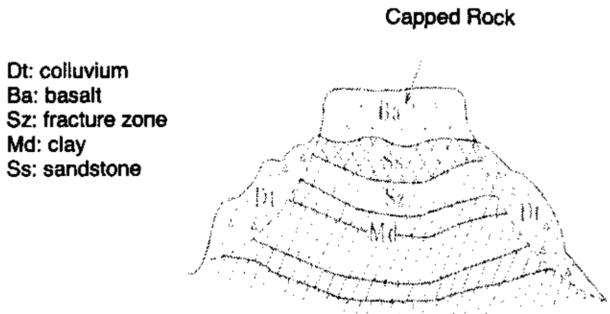
vi) Capped rock structure

Where there is a hard rock cover, i.e over a vulnerable stratum, the hard rock is not easily weathered and it has a low sliding potential. However, the soft stratum beneath the rock has a high potential for sliding and crumbling down (Figure 3.5.16).



Fracture zone caused by an andesitic intrusion

Figure 3.5.15
Model of the Slide of a Colluvial Deposit due to the Intrusion of Andesite



Slide face in the bottom of a colluvial deposit

Figure 3.5.16
Model of the Slide of a Colluvial Deposit due to Capped Rocks

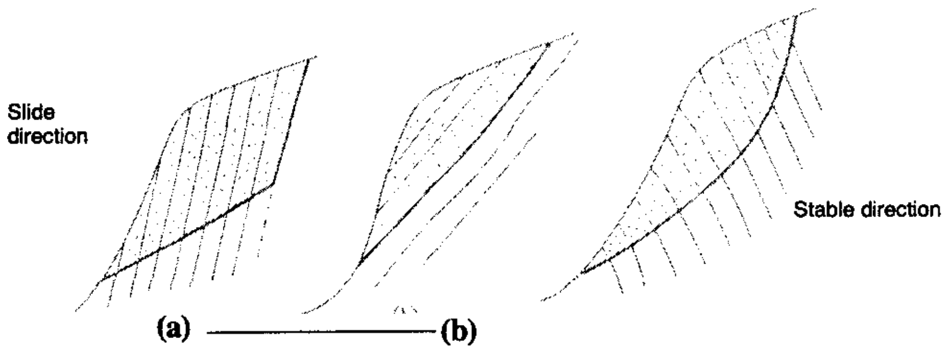


Figure 3.5.17 Sliding along a Slide Direction and a Stable Direction

b) Period and Quality of The Bedrock

The classification of the period and quality of the bedrock shall be done as shown below. For the actual selection, it shall consult with geological maps, etc.

[1] Strata from the Paleozoic and Mesozoic ages (Crystalline rock, Sedimentary rocks)

[2] Strata from the Tertiary Period (Sedimentary rocks)

[3] Strata from the Quaternary Period (Non-solidified sediments, Sedimentary rocks)

[4] Other (Volcanic rocks, Igneous rocks)

c) **Inflow Water**

Spring is an important factor of slope slides, particular inflow water. It infiltrates from the upper side of the slope and goes out around the foot of the slope. Inflow water tends to concentrate primarily around the feet of the both sides of terrains formed by slope dslides (Figure 3.5.18).

Even if water from is not observed at the inspection, there are traces of inflow water, should be assumed that that site has inflow water in that place.

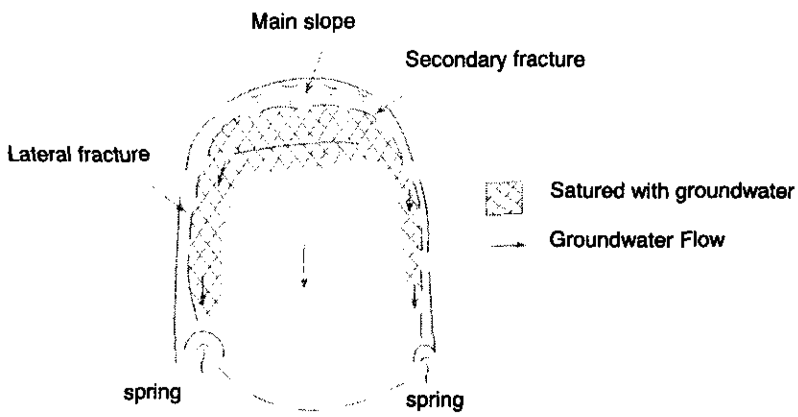


Figure 3.5.18 Inflow water Channel System in a Slope slide Terrain

(2) **Evaluation History of Slope slides**

1) **History of Slope slides**

This is an inspection of the occurrence of slope slides in the past.

The inspection should be done through the records of slope slides at road management offices, or reliable local legends. Some other sources can be used, as per below:

a) **Interviews to the Local Citizen**

Collecting information around the site, dimensions and damages from past slope slides through interviews to local citizen.

b) **Records of Slope Slides**

Collection data at the provincial and district offices.

2) **Symptoms of Slope Slide**

A slope slide's own activity generates some symptoms, such as cracks or subsidence of soils, to appear on the surfaces of roads, and structures (Figure 3.5.8). However, the symptom is not always clear, and therefore it is important to proceed very carefully during the inspection. When cracks in the surface of a road are covered with overlay, the cracks should be evaluated as symptoms of previous symptom of slope slides. The main symptoms are the followings:

a) Cracks on Natural Slope

i) Primary crack, secondary crack

These are tension cracks, which appear at the head of terrains formed by slope slides, which are perpendicular to the direction of the movement, and have the shape of a horseshoe or a straight line. This type of cracks is made of the subsidence of the head of the terrain formed by slope slides, while it is made of the horizontal displacement of soil masses (Figure 3.5.9, Figure 3.5.19).

ii) Cracks in the sides of slide terrains

Cracks appear in sides of terrains, are formed by slope slides. It is very clear under the actual activity, and immediate after it. However, it is difficult to identify it later, sometimes erosion creates ravines on it. Cracks in the sides of terrains are classified as closed cracks and open cracks (Figure 3.5.20).

iii) Compression cracks

They are formed due to the compression of soil masses around edge. These open cracks occur, either parallel or 30° against the sliding direction. These cracks are open, but it have not difference level such as step shape.

b) Upheaval

A small expansion can be seen in the edge portion of the terrain. In general, the middle area of the terrain expands very much. When there are cracks in the sides of the terrain under displacement, the head protion exhibits staggered subsidence, and lower part exhibits an upheaval (Figure 3.5.9). When there is pressure from different directions of that slope, the area is elevated under pressure in the sides of the sliding terrain.

c) Subsidence

There are two types of subsidence:

i) It is due to a tension crack in the head of the terrain,
ii) the second type is due to an open crack in one of the sides.

Subsidence of the head occurs when a straight line is formed along the glide plane. Due to deformation in the point in where the head and the base reach, a mass of soil is made, near the glide plane. Because of the movement, the soil mass falls into the crack and subsidence occurs (Figure 3.5.19).

Subsidence in the side of the terrain occurs because of the force by different direction of the natural slope, which originates the open crack, and, as a result, a ravine-like area is formed.

d) Abnormality and Deformation of Countermeasure Works for the Slope Stability

Symptoms of slope slides, like displacement of construction joints, expansion, undulation and cracks in the structure, appear in countermeasures for slope stabilization works (Crib works, Retaining walls). In addition to direct movement due to slope slide activities, the superficial movement provoked by sliding soil generates these symptoms as well.

e) Small Collapse

Sometimes small collapses appear in the upper and lower extremes of the glide slope.

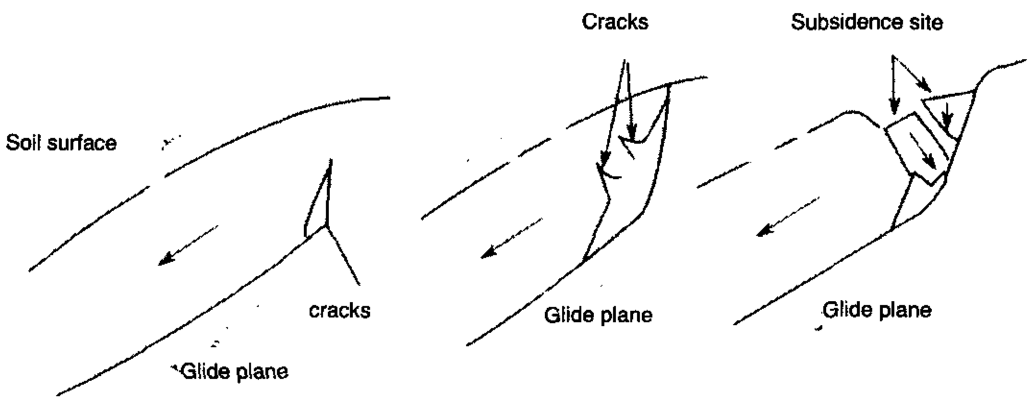


Figure 3.5.19 Appearance of Subsidence due to Slide in the Form of a Chair Shape

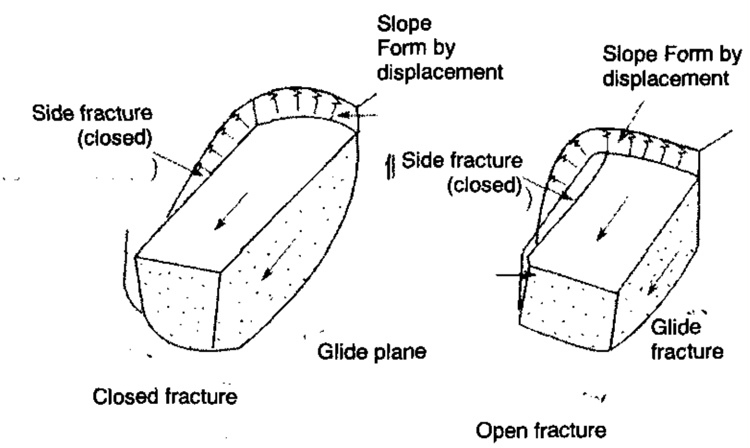


Figure 3.5.20 Fracture in Side

The symptoms of a slope slide should be classified in three categories, as "Clear", "A little clear" and "Nor exist". When a determination cannot be made clearly, the superior category should be selected.

i) Clear symptoms

Clear symptoms are the following:

[1] Appearance step-like disposition due to tension cracks in the head, or open cracks which are clear and continuous,

[2] Continuous secondary cracks are seen in the head,

[3] Expansion, upheaval and compression cracks are found in the lower edge part of the terrain,

[4] At the same time, tension cracks (without step-like disposition nor open cracks) appear at the head, and upheaval and compression cracks (not so notorious) in the lower edge part of terrain,

[5] There are cracks, either continuous or non-continuous, in side of the block of the slide terrain,

[6] Relatively new subsidence is observed in the head or side,

[7] A crack appears in the wall, and differences occur,

[8] There is a notorious displacement of construction joints in a wall,

[9] It is observed the inclination and subsidence of structures in function of tension in the upper side and compression in the lower side,

[10] Small collapses appear in the head and the lower edge part.

ii) A little clear symptoms

The not-so notorious symptoms of a landslide are the following:

[1] There are tension cracks in the head which has not step-like disposition or open cracks,

[2] There are cracks in the wall,

[3] There is displacement of construction joints,

[4] There is signs of undulation on countermeasures of slope stabilization works,

[5] There is displacement of construction joints of Pre-cast crib works.

iii) There are no symptom

There are no symptoms

(2) Evaluation to the Effectiveness of Existing Countermeasure Works

1) Effectiveness of the Existing Works

The degree of efficiency of existing works to prevent slope slides, should be determined as follows:

a) High Efficiency

All works necessary are completed for prevention. Slope slide has never occurred after completion of countermeasure.

b) Some Efficiency

i) In case of works intended to reduce groundwater

Works to reduce the amount of groundwater has already done, and the efficiency of drainage is confirmed, but it is not yet confirmed whether the groundwater level is reduced as much as expected.

ii) In case of protection works, earth works, embankments for stability.
Even if protection works for slope slide are finished, , it is necessary to take further measures for prospective new mass slide .

c) No Treatment works have been done, or their Efficiency is Low

i) The countermeasure works have not been made yet.

ii) Block works and retaining walls were made only to protect slopecollapse at the lower edge part (repairing the retaining wall and overlay for the road cannot be considered as works for slopeslide protection).

Table 3.5.2 Record by Inspection Site

Format-3-1

No.			Inspection Item		Name of the road		Kilometer post (of)		(to)		From Managua / To		Total m.
Clasification	Toll / Common	Category		Name of the site			Site mark		Latitude		Longitude		
Traffic Restriction	Yes (Crossing/Special) Not		Restriction Criteria		Traffic Volume	Day of the week	Holliday		DID	Yes No	Bus Route	Yes No	Detour	Yes Not

Pictures of the site, Sketch (to indicate the location of the existimg works and the site mark)	Location map (scale 1/50,000)

Special remarks:

Inspection Date: / / (Weather: clear・cloudy・rain)

Method of inspection:

Note:

Disasters history	Yes (1. See damage record, 2. unknow details:) Not
Other inspection objectives	Exist or Not *Rock fall, collapse, rock mass collapse, land slide,* debris flow, embakment, retention wall, bridge, others
Inspection result of year	Score: (Completed・In execution・Not started) Countermeasure:
Inspection result of 2002 year	Score: Integral evaluation: 1. It's necesary to take measures: 2. Response, making prescription of prevention: 3. It's not necesary to take measures:
Forecast of disasters dimension	
Proposal countermeasures	Kind of work: Norm: Quantity: Preliminary cost:
Stability in case of seism (for rock fall & collapse only): stable / unestable	

Table 3.5.3 Stability Investigation Table

Nombre	
Organización	

Stability Investigation Table (Slopeslide)

[Factor] (A)

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

[Historial] (B)

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

(C)=MAX(A,B)

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

[Threatment work] (D)=C)+ ó (C)×0

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

[Integral Evaluation]

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

Table 3.5.4 Record of the History of Damages

Form - 5-1

No.		Type of disaster		Site	Kilometer post (of)	(to)		From Managua/ To	
Inspection Site Year	Respond / Not Respond				East longitude		North Latitude		

Plane (Damages, Measures)	Seccion (Damages, Measures)

Pictures, Sketch of actual situation	Remarks	
	Date of disasters	
	Dimension	Wide, Long, Depth (m) m, m, m
	Inciding factor	Precipitation: Continue mm/ hr·d Maximum m Earth quake: Magnitude
	Damages	Human damages: deads Injuries: Material damages: Total cost of damages loss: Comments:
	Traffic restriction record	1.Full restriction: hours 2. One way road restriction: hours. 3. Others:
	Countermeasure	Year of construction: Type of works: Approximate Cost:

3.6 Method for the Evaluation of Stability: Embankment

3.6.1 General

(1) Rating based on factors, countermeasure work, and history

Generally, collapse of road embankment due to rainfall occurs with high frequency when including small ones, accounting for about one half of disasters of face of slope and natural slope caused by rainfall.

The governing factor for collapse of embankment by rainfall is localized water collection, such as infiltration of rainfall and groundwater, scouring with running water, etc. Therefore, site investigation must be made during inspection, with due attention paid on the possibility of such water collection.

The rating concept is as follows. Firstly, the stability of embankment of each section is evaluated from two viewpoints; the possibility of collapsing induced by water collection and the occurrence state of past disasters. Concerning the possibility of collapsing, the rating of stability is determined by adding the effects of countermeasure work to the rating based on factors responsible for occurrence.

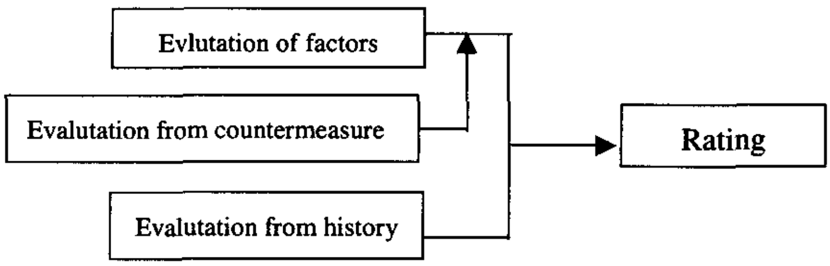


Figure 3.6.1 Concept of Stability Survey (embankment)

On the other hand, the possibility of damage to the embankment due to rainfall and water collection and the damage condition vary greatly depending on the circumstance in which the embankment exists. Therefore, embankment conditions are divided as shown in Figure 3.6.2. The embankment is divided roughly into two portions; the half-bank and half-cut, along which stormwater falling onto the natural slope and the face of slope in the upper portion of embankment runs down to reach the road surface and the face of embankment slope, and both-banking on which rainwater does not reach the road surface and the face of embankment slope. Both-banking is further divided into four portions according to topographical conditions; banking on a flat ground, embankment on a slope, embankment traversing a mountain stream, and embankment at boundary of cutting and filling. Embankment on the slope may have a possibility that flowing water from the upstream area collects at the toe of specific embankment slope.

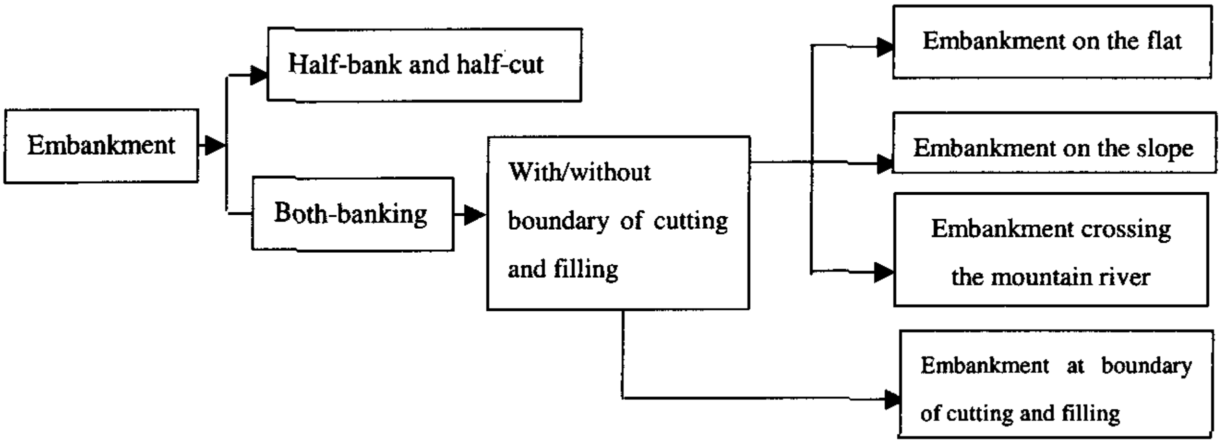


Figure 3.6.2 Classification of embankment conditions

(2) Overall evaluation

For overall evaluation, the professional engineer performs overall review of the scale and effects of disasters while referring to (1) factors of disasters, (2) effects of countermeasure work, (3) history of disaster, and (4) surrounding condition. The future countermeasure policy is evaluated in three stages as follows:

● It is necessary to take measures	There is a potential for disaster in the site
● To answer, making a table of the "Disasters Prevention "	There is a need to take measures in the future, but, at the moment, control is to be exercised through vigilance as per the "Prevention Table"
● It is not necessary to take new measures	The site shows no disaster factors and there is no need to take new measures.

(3) Factors to be taken into account during rating of the stability

1) Deformation

Any latent destabilizing factor in or around the embankment body often leads to certain deformations in the body. Therefore, the stability of embankment can be checked by checking the embankment body for deformation.

2) Foundation ground

There is no particular problem when the ground on which embankment is constructed is stable. But the unstable ground (movable mass, talus, etc.) may cause sliding of ground, resulting in deformation of embankment. Therefore, the ground check is necessary at a location where embankment is constructed.

3) Banking material

Sandy soil allows easy penetration of water and readily suffers deterioration of the strength due to water content. This type of soil has low resistance against scouring and develops collapse with ease. In this context, adequate classification of banking materials is necessary by understanding their physical properties.

4) Effects of groundwater and surface water to embankment

Penetration of groundwater and surface water into the embankment body causes increase in the pore pressure, often resulting in sliding of the top of embankment slope. Surface water (water flowing down along the upstream side natural slope and road surface) may also cause scouring of the slope face. Check must be made on whether not groundwater or surface water exerts adverse affect on the embankment.

5) Condition of the mountain river

When the mountain river traverses the embankment, debris flow or running water of the mountain river may cause disaster to such embankment. Therefore, check must be made on whether or not there is any trace of debris flow in the river, the topography or facility allows ready water collection to the inlet to the crossing drainage facility, and the crossing drainage facility is sufficient.

6) Effects of rivers and waves

The toe of slope of embankment (legs of retaining wall, face of embankment slope) may suffer erosion under water hammering in the normal condition and when submerged in the abnormal condition (inundation, high water). When the outfall of crossing drainage facility of embankment is submerged, the discharge capacity of such facility is deteriorated, with resultant overflow at the inlet causing damage to the embankment. Check must therefore be made on the effects of river water and waves on the toe of slope or the crossing drainage facility.

7) Countermeasure work

There are various countermeasure works against assumed damage patterns and risk factors. If the adequate countermeasure work is provided for each factor, there should be no concern of damage expected by such factors. When there is any countermeasure work, therefore, compensation must be made toward enhancement of the stability.

8) Disaster history

If the section concerned has ever suffered damage, thorough measures have been taken generally concerning such damage. In case that the expected scale of damage is larger or the countermeasure work is aged, evaluation must be made while taking into account the possibility of suffering disaster again.

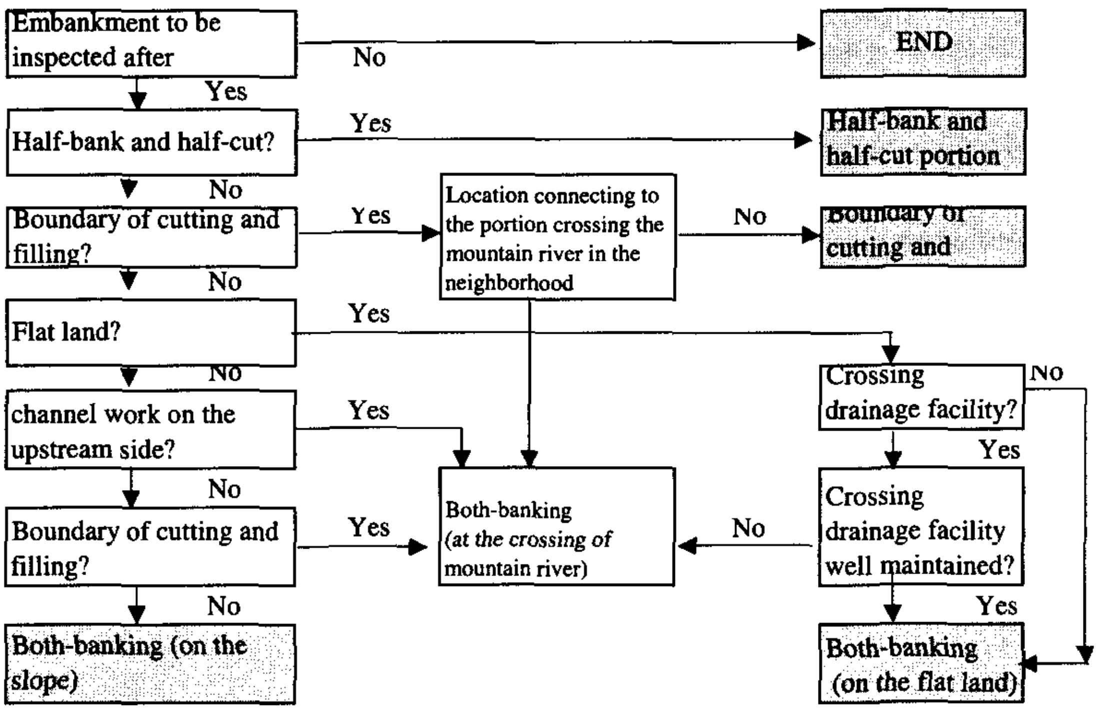
3.6.2 Stability review table and entry procedure

Table 3.6.3 shows the review table on collapse and washout of embankment during rainfall. The procedure for entry in this table is described below. In this case, the section where the embankment condition does not change much and may be considered approximately similar is taken as one unit of embankment.

(1) Classification of embankment

In this evaluation, one embankment is classified into either a half-bank and half-cut portion (including widening of embankment) or a both-banking (on the flat land, on the slope, at crossing of mountain river, and at a boundary of cutting and filling). Evaluation is made on the stability during rainfall. Adequate classification of embankment is the most important for the stability evaluation because factors and the method to allocate marks differ among classified embankments. Items 1) and 2) show the embankment classification method. Figure. 3.6.3 shows the flowchart of embankment classification.

Figure. 3.6.3 Embankment classification flowchart



1) Half-bank and half-cut (Fig. 3.6.4)

This is a configuration occurring generally when the road is constructed in the natural slope. The road surface is secured by cutting the natural slope on the mountain side and by banking on the natural slope on the valley side.

Widening of embankment is also included in this classification. The half-bank and half-cut portion suffers ready penetration of groundwater from the ground while being adversely affected by the surface water from the cut slope. Important checkpoints in this case include treatment of groundwater and surface.

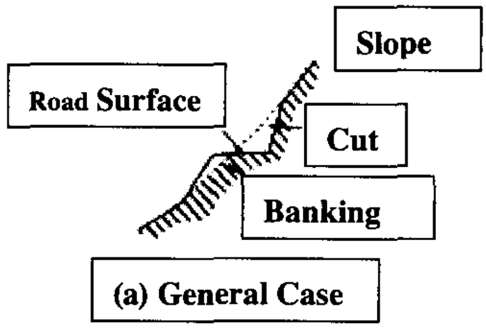


Fig. 3.6.4
Half-bank and half-cut portion

2) Both-banking

a) Both-banking portion

(Crossing point of mountain river. Fig. 3.6.5)

This type of embankment is used in combination with a bridge. box culvert, etc. when the road is to cross the mountain river or channel. Disaster of road embankment occurs mostly at the crossing point of mountain river. An important checkpoint is whether or not the channel work and crossing drainage work in the mountain river has been well developed.

Entry in this review table covers a case in which the surface water exists and a case in which the trace of running water is visible as in the case of gully, scouring, etc. though there is not any steady running water. However, the abutment, etc. is not covered when the channel work is on the flat land and well developed, without any adverse effect of the river water on the embankment.

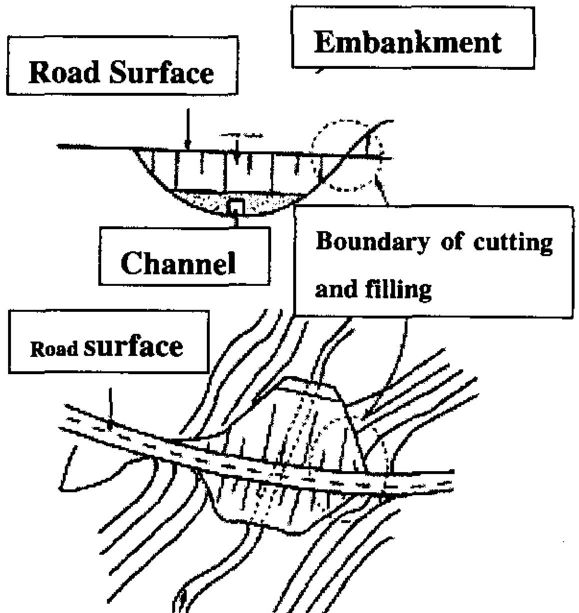


Figure 3.6.5
Both-banking portion
(crossing of the mountain river)

b) Both banking portion (on the slope. Fig. 3.6.6)

This configuration occurs when the road is constructed in the parallel slope or the loose concave slope. Both-banking is made though there exists a difference in the embankment height between mountain and valley sides.

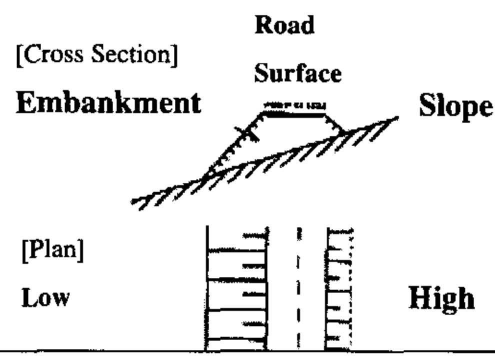


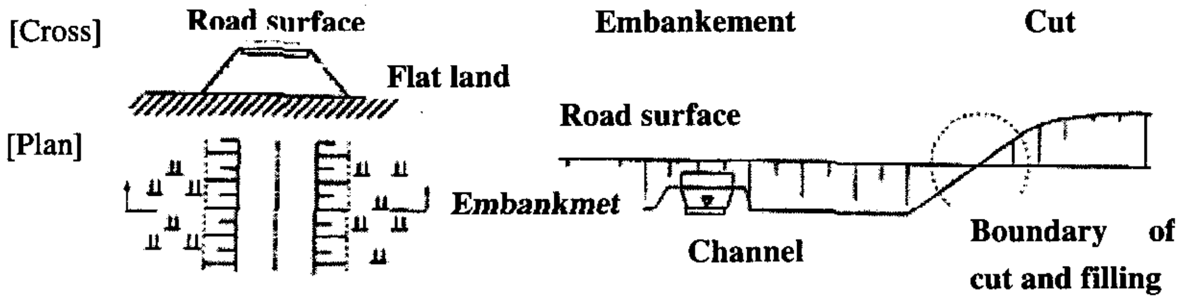
Figure 3.6.6
Both-banking portion (on the slope)

In this both-banking portion (on the slope), the face of slope is washed out by the road surface water or the rainfall onto the upstream side slope causes ready penetration of water from the toe of embankment slope (on the upstream side) into the embankment, as in the case of Fig. 3.6.7, Both-banking. The important checkpoint is therefore treatment of the road surface water and rainfall onto the upstream side slope.

c) Both-banking portion (on a flat land. Fig. 3.6.7)

This is the commonest configuration occurring when the road is constructed in the flat land, *such as the bottomland on the downstream side of rivers (including alluvial fan and delta), in* the valley floor lowland of the hilly terrain or mountainous area, and artificial landfill.

In the both-banking portion (on the flat land) located next to half-bank and half-cut portions, the surface water running down along the road surface outflows onto the face of slope, causing scouring and resulting in damage. The important checkpoint is whether or not the surface water flows out onto the face of slope or the water running down along the road surface during rail fall is large.



General configuration Configuration with a boundary

Fig. 3.6.7 Both-banking portion (on the flat land)

d) Both-banking portion (at a boundary of cutting and filling)

This embankment configuration occurs when both-banking portion connects to the cut or natural slope. As the surface water from the cut slope or road surface tends to collect readily at the toe of slope, disasters have occurred often, including scouring from the face of embankment slope to the embankment body. The important checkpoint is therefore whether or not the gutter at the boundary of cutting and filling or its capacity for terminal treatment is sufficient. (See Fig. 3.6.5 and Fig. 3.6.6) Note that the boundary of cutting and filling next to the crossing point of mountain river as shown in Fig. 3.6.5 is handled as a crossing point of mountain river during evaluation.

(2) Evaluation based on factors

1) Destabilizing factors latent in embankment and their viewpoints

Following risk factors may be derived from embankment disaster cases by rainfall.

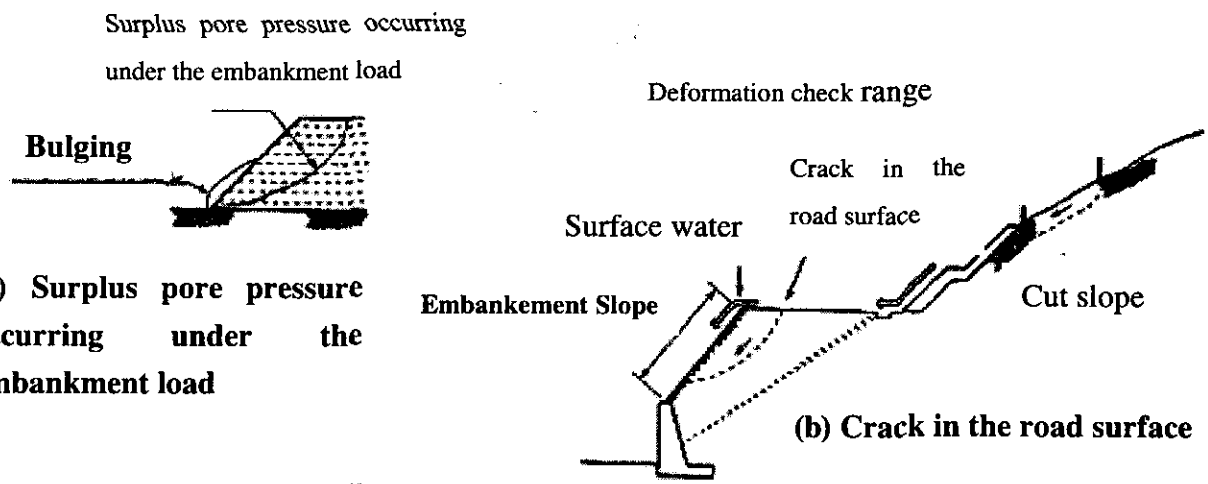
In this review table, all of matters related to individual risk factors are extracted. When multiple matters fall into a factor, the highest mark allotted to a certain matter is used as a rating. "0" is allotted when there is not any applicable matter.

a) Deformation

Deformation occurs not only in the embankment body, but also other locations where failure presents adverse effect on the embankment body, such as scouring of the natural slope in the lower part of (valley side) face of slope.

A structural deformation is a particularly important index. Structural cracks and opening cracks include bulging of earth-retaining walls.

Deformation include the minor one (stable in the present state) involved in settlement due to insufficient consolidation of embankment materials or the dead weight of structures (retaining walls, etc.) and the structural one (that may possibly extend in the future) involved in sliding of the embankment shoulder. In the latter case, seepage or surface water may cause further development of deformation of the embankment body. Therefore, it is essential to grasp factors responsible for deformation and to evaluate whether or not such deformation is structural. Arcuate crack and depression in the road surface, bulging in retaining walls are likely to be structural deformation. (See Fig. 3.6.8)



(a) Surplus pore pressure occurring under the embankment load

(b) Crack in the road surface

Figure 3.6.8 Typical structural deformations

d) Effects of groundwater and surface water on embankment

Penetration of groundwater and surface water from the ground and cut slope (natural slope) often causes sliding and collapse of the embankment slope shoulder. As such water penetration is a critical factor for sliding and collapse, it must be provided with large weight along with the running water of mountain river described later, among stability evaluation factors, and incorporated in the stability review table. In particular, embankment on the slope ground, embankment filling a valley, half-bank and half-cut, boundary of cutting and filling suffer often instability in the slope because of penetration of the spring (groundwater) and surface water from the ground into the embankment, Even when there is steady running water, there would be no problem if the drain facility of gutter and vertical ditch is functioning satisfactory during heavy rain. In this context, checking of water treatment is important.

It is difficult to determine in the site whether or not groundwater has penetrated into the embankment body, so that the toe of slope of the body including retaining walls is checked for any wetness. (If undergrowth on the top soil does not dry up even in winter, the groundwater level under the embankment is often high.)

Whether the surface water from (cut and natural) slopes and road surface flows down to the face of slope can be judged by checking for trace of running water, such as gully, bog moss, etc. Particular attention must be paid on a fact that concentration of flowing water from the road surface to the slope at specific points often causes scouring of the slope and collapse of the road surface .

When the ground similar to the one on which the embankment has been constructed is confirmed in the neighborhood and there is a possibility of spring from this ground, there may be a possibility that the spring has penetrated from the ground into the embankment. Note also that, in the case of both-banking portion (on the slope), the spring on the upstream side may become the surface water as a result of gradient, penetrating into the embankment. In particular, due care must be taken when there is no gutter at the toe of slope.

Embankments proving these possibilities correspond to "Spring in the face of slope and natural slope" in the review table.

Note also that seepage water penetrating into the embankment tends to increase when the land around the embankment are a rural country, lakes and marshes, or swamp. This case corresponds to "Surrounding land use wet" in the review table.

e) Condition of mountain river

Disaster cases of road embankment indicate that disaster occurs most frequently at the crossing point of mountain river. The most frequent case is that debris flow occurring in the mountain river blocks the inlet of ditch, causing overflow or the embankment itself is washed out under impact of debris flow.

This is followed by overflow caused by faulty water collection to the inlet of ditch due to the curved channel alignment or insufficient section of ditch.

Evaluation on the condition of mountain flow is made in two steps; the condition of mountain river (upstream) and the present condition of crossing drainage facility. The highest mark for each condition is used for rating. It is recommended to interpret the collapse land on the upstream side of mountain river by using existing aerial photographs.

In the case of half-bank and half-cut portion, the crossing drainage facility may not exist in certain cases even when trace of running water exists (gully, etc.) on the cut (mountain side) slope.

Certain old roads in the mountainous area may not have the drainage facility crossing the embankment even in the topography with mountain river. Particular care is necessary in this case because it is highly probable that scouring of the face of slope and collapse of the road surface occurs.

When the terminal (outlet) of crossing drainage facility is not covered with concrete, water discharged from the ditch may cause scouring, resulting in collapse of the surrounding ground. It is therefore essential to check if terminal treatment is sufficient.

Soil or driftwood may be accumulated in the drainage facility, causing deterioration of the discharge capacity in many cases. In such cases, the existing section allowing water to flow is assumed as the ditch section during evaluation.

Note) Evaluation of "No drainage facility" in "Present condition of crossing drainage facility" for half-bank and half-cut portion and both-banking portion (at the crossing point of mountain river) is made only when the "Present condition of mountain river" is determined to be "No steady running water, but gully."

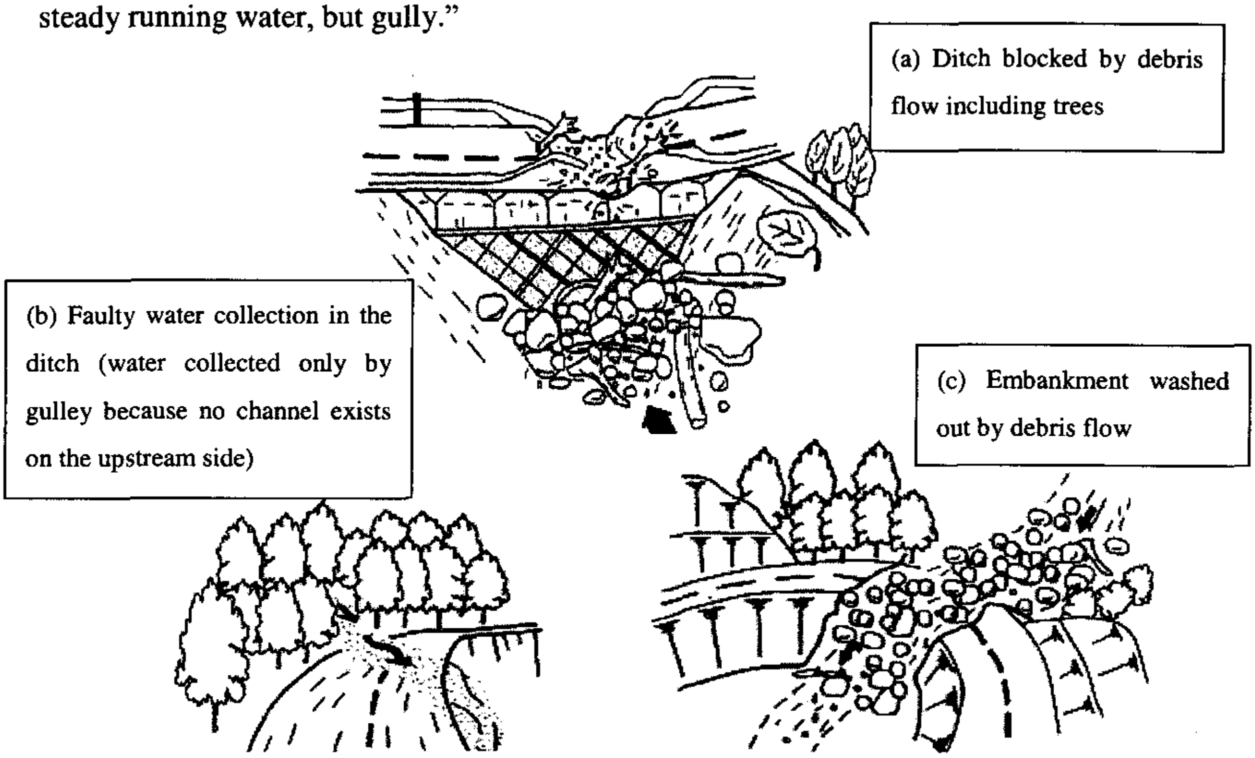


Figure 3.6.9 Typical disasters of the face of embankment slope at the crossing point of mountain river

(3) Evaluation based on factors

c) Measures against groundwater and surface water

When the groundwater drainage stratum or drainpipe is provided to enable rapid drainage of penetrating groundwater and surface water and when the top soil of embankment body is covered with the slope protection such as shotcrete, lining, etc., they may be expected to prove effective to a certain extent. On the other hand, gutter and surface drainage may often prove ineffective due sand accumulation or fallen leaves, so that they must be entered under the column "Others, none." Table 3.6.1 shows the type of actual measures against deformation and groundwater/surface water, indicating which countermeasure falls in which countermeasure type in the table.

Table 3.6.1 The type of actual measures against deformation and groundwater/surface water

Classification	Type	Purpose and features	Measures against deformation	Measures against groundwater and surface water
Vegetation	*Hydoro Seeding* Vegetation	Prevention of erosion		Planting pitch work
Slope face protection with structure	Stone Pitching Shotcrete Precast cribwork	1)Prevention of weathering and erosion 2)Prevention of erosion in case of filling with soil or cobble stone	Control work	Surface coverage
	Concrete-block pitching Sprayed Concrete Crib Cast-in concrete form work Rock bolt, Anchor work	1)Earth retaining of the location possibly subject to more or less earth pressure 2)Earth retaining of the location possibly subject to more or less earth pressure 3)Prevention of rock spalling	Permanent Stractural Measures	Slope form work with Anchor
	Wire net work Gabion	Prevention of erosion of slope face layer or its washout by spring	Control work	Planting pitch work
	Prevention Net			
	Gabion wall Stonen masonry wall Grabity Type retaining wall T-shaped retaining wall Pilling Embankment(Addition)	Resistance against certain earth pressure (Prevention work)	Permanent Stractural Measures	Slope form work

(4) Evaluation based on the disaster history

1) Consideration of existing disaster

Disasters caused by rainfall and water collection, such as those caused by debris flow, are considered to be repeated unless the topographical conditions are greatly changed. Therefore, data must be collected on existing disasters before construction of the present embankment. The stability is evaluated substantially low in case of lack of sufficient measures when disasters existed in the past and their scale was large.

Note) Sufficient measures are not ad-hoc repairs, but rehabilitation for long-term stabilization of structure.

Table 3.6.2 Record by Inspection Site

Format-3-1

No.		Inspection Item		Name of the road		Kilometer post (of)		(to)		From Managua / To			Total m.
Clasification	Toll / Common	Category		Name of the site		Site mark		Latitude			Longitude		
Traffic Restriction	Yes (Crossing/Special) Not	Restriction Criteria		Traffic Volume	Day of the week	Holliday		DID	Yes No	Bus Route	Yes No	Detour	Yes Not

Pictures of the site, Sketch (to indicate the location of the existimg works and the site mark)	Location map (scale 1/50,000)

Special remarks:

Inspection Date: / / (Weather: clear·cloudy·rain)

Method of inspection:

Note:

Disasters history	Yes (1. See damage record, 2. unknow details:) Not
Other inspection objectives	Exist or Not Rock fall, collapse, rock mass collapse, land slide, debris flow, embakment, retention wall, bridge, others
Inspection result of year	Score: (Completed·In execution·Not started) Countermeasure:
Inspection result of 2002 year	Score: Integral evaluation: 1. It's necesary to take measures: 2. Response, making prescription of prevention: 3. It's not necesary to take measures:
Forecast of disasters dimension	
Proposal countermeasures	Kind of work: Norm: Quantity: Preliminary cost:
Stability in case of seism (for rock fall & collapse only): stable / unestable	

Table 3.6.3 Stability Investigation Table

Inspector's Name	
Organization	

Stability Investigation Table (Embankment)
[Factor A]

Factors		Classification for rating	Mark for each embankment classification: Half-bank and half-cut	Both-banking: Crossing point of mountain river	Both-banking: On the Slope	Both-banking: On the flat land	Both-banking: At the boundary of cutting and filling	Evaluation Grade (Score)
Deformation		Structural crack and opening crack existing	2	2	2	2	2	
		Scouring found in the lower layer of slope face	3	3	3	3	3	
		Many repair locations	2	2	2	2	2	
			1	1	1	1	1	
		Not applicable	0	0	0	0	0	(3)
Foundation ground		Landslide, creep	2	2	2	2	2	
		Soft ground	1	1	1	1	1	
		Grain size	1	1	1	1	1	
		Stable ground	0	0	0	0	0	(2)
Embankment materials		Sandy	1	1	1	1	1	
		Clayey	0	0	0	0	0	
		Conglometate	0	0	0	0	0	
		Not known	1	1	1	1	1	(1)
Effects of groundwater and surface water on the embankment		Wet toe of slope	6	6	6	6	6	
		Trace of running water on the face of slope	6	6	6	6	6	
		Spring water in the face of slope and natural slope	6	6	6	6	6	
		Wet sroundding land use		2	2	2		
		Not gutter at the toe slope			2			
		Insufficient section of the gutter and ditch drainage facility	4	4	4	2	6	
		Not applicable	0	0	0	0	0	(6)
Condition of mountain river	Present condition of mountain	Debris flow in the river. Driftwood	3	3				
		Collapse land on the upstream side	2	2				
		Gully without steady running water	2	2				
		Faulty water collection to the inlet of drainage work	2	2				
		Not applicable	0	0				(3)
	Present condition of drainage	Insufficient ditch capacity	6	6				
		Insufficient water treatment of drainage work	3	3				
		Curve or size reduction of drainage work in embankment	3	3				
		No crossing drainage facility	6	6				
		Not applicable	0	0				(6)
Effects of river water and wave		Toe of slope submerged during inundation and high water	2	2	2	2	2	
		Edge of drain submerged during inundation and high water	2	2	2			
		Toe of slope normally submerged (at boundary of cutting and filling)	1	1	1	2	2	
		Toe of slope normally submerged	1	1	1	1	1	
		Not applicable	0	0	0	0	0	(2)
						Total		0

[Threatment Work] (B)=(A)+α

Objective	Classification	Score(α)	Evaluation
Measures against deformation	Permanent Structural measures	-4	2
	Control work	-2	
	Others/none	0	
Measures for foundation	Antiearthquake work and reinforcement of foundation	-2	
	Others/none	0	
Measures against groundwater and surface water	Works against groundwater, slope frame work with anchor	-4	
	Slope frame work, surface coverage	-3	
	Slope face drainage work, plant pitching work	-2	
	Ditch	-1	
	Others/none	0	
Measures against mountain river	Dam, simple check dam	-5	
	Channel work on up and downstream sides, earth-retaining wall	-3	
	Channel work on the upstream side	-2	
	Channel work on the downstream side	-1	
	Others/none	0	
Measures against river water and wave	Earth-retaining wall (dry walling excluded)	-1	
	Others/none	0	
	Total	(α) 2	(B) 2

[Total Evaluation] (Conversion of rating) (B)→(C)

(B)	<0	0,1	2,3	4,5	6,7	8,9	10,11	12,13	14,15	>16
(C)	0	10	20	30	40	50	60	70	80	90
							Total (C)			

[Record] (D)

Item		Classification	Score	Evaluation
Disaster		Yes	+30	
		No	0	
Scale		Total collapse of embankment (road closed)	+70	
		Partial collapse of embankment (road closed)	+60	
		Surface erosion (traffic on one side only for a few days)	+45	
		Minor damage (opened for traffic on the day)	+40	
Measures		Total rehabilitation of embankment, sufficient measures	-70	
		Repair Ad-hoc measures	-30	
		Measures similar to those before disaster, no measures taken	0	
		Total	(D)	0

(E)=MAX(C,D)

Evaluation grade of the factor	(C)	
Evaluation grade of the History	(D)	0
The highest between A and B	(E)=MAX(C,D)	0

[Total Evaluation]

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

Table 3.6.4 Record of the History of Damages

Form - 5-1

No.	Type of disaster		Site	Kilometer post (of)	(to)	From Managua/ To	
Inspection Site Year	Respond / Not Respond			East longitude		North Latitude	

Plane (Damages, Measures)	Seccion (Damages, Measures)

Pictures, Sketch of actual situation	Remarks	
	Date of disasters	
	Dimension	Wide, Long, Depth (m) m, m, m
	Inciding factor	Precipitation: Continue mm/ hr-d Maximum m Earth quake: Magnitude
	Damages	Human damages: deads Injuries: Material damages: Total cost of damages loss: Comments:
	Traffic restriction record	1.Full restriction: hours 2. One way road restriction: hours. 3. Others:
	Countermeasure	Year of construction: Type of works: Approximate Cost:

3.7 Method for the Evaluation Of Stability: Debris Flow

3.7.1 General

(1) Evaluation of Factors, Treatment Works, Road Structures and History

Road disasters is caused by debris flows should be dealt with not only from the point of view of the conditions for their occurrence, but also considering their relationship with the roads facilities in which it cross a ravine. Therefore, the evaluation of stability concerning debris flows has to be carried out items shown below.

The evaluation should be carried out factor of ratings focus on the features of the slope, including ratings of countermeasure works, road structures, and total score for each items. Finally, the score for stability should be compared and chosen the higher rating of the total previous evaluations and history of disasters. Highest score correspond to the evaluation of stability.

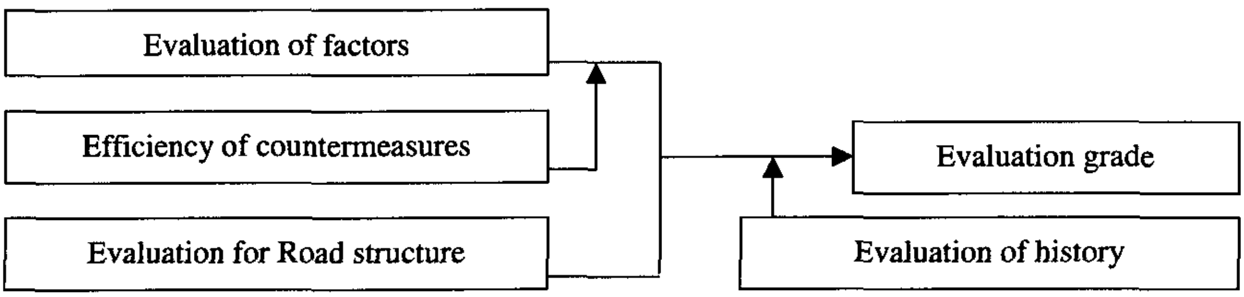


Figure 3.7.1 Concept of Stability Evaluation Ratings

(2) Integral Evaluation

The engineer considers the scale and the influence of natural disasters from following items;

i) Disaster factors,
ii) Efficiency for countermeasures,
iii) Road structures,
iv) Disaster history, and
v) Conditions of the areas surrounding the site.

Then the necessary answer is selected from the three categories shown below;

● It is necessary to take measures	There is a potential for disaster in the site
● To answer, making a table of the "Disasters Prevention "	There is a need to take measures in the future, but, at the moment, control is to be exercised through vigilance as per the "Prevention Table"
● It is not necessary to take new measures	The site shows no disaster factors and there is no need to take new measures

(3) Factors to be considered for the Evaluation Score of Stability Survey

i) Catchments area of the basin

ii) Maximum inclination of the ravine bed

iii) Features of the slope

iv) Degree of efficacy of existing countermeasure works

v) Rectification for road structures where it cross the ravine.

The road structure in the ravine area influence the magnitude of disasters, are many items such as the extent area of the debris flow, the free space below the bridge's main beam, the width of the channel, and the form of the ravine , etc.

Then, it is adopted the method which consists of evaluating the free space below the bridge and the width of the channel.

vi) History of disasters

(4) Other Necessary Items

Basic forest plan (scale, 1/5,000), aerial photographs (approximate scale, 1/10,000).,etc.

3.7.2 Stability Inspection Table and Guidelines

(1) Evaluation of Factors

The following factors should be evaluated for the ravine under inspection. The survey is to be carried out primarily at the office.

1) Characteristic of the Ravine

i) The potential catchments area of the debris flow.

ii) Maximum inclination of the ravine

2) Characteristic of the Slope

i) Area, which is covered by the slope which inclination is steeper than 30°.

ii) Surface with grass and bushes (plants with a height less than 10 meters).

iii) Existence of earth works on unstable soils; existence of earth works on unstable soils with an inclination steeper than 15°

iv) Existence of new slide with fissure; It is the case to be recognized by aerial photographs (with an approximate scale of 1/10,000)

v) History of relatively large scale slides; It is the case to be recognized by aerial photographs (with an approximate scale of 1/10,000), and the magnitude of the disaster is covered area from the bottom of the ravine up to the highest point of the slope, and the width of the trace is almost equal to that of its height.

(2) Evaluation of the Efficiency of Existing Countermeasure Works

1) Rectification of Efficiency through Treatment Works done at the Ravine.

It is to be evaluated as per Table 3.7.1

Table 3.7.1 Rectification of Efficiency of Existing Works

Evaluation	Total Height of the Free Dam Space Existing in the Ravine (meters)			
	0 meters	0 - 14 meters	14 - 28 meters	Over 28 meters
	None, low	Normal	High	Sufficient

Note: The "free dam space" is the difference between the height of the dam and the level of sediments. "Total height" is the sum of the free space of several dams (if there are several dams).

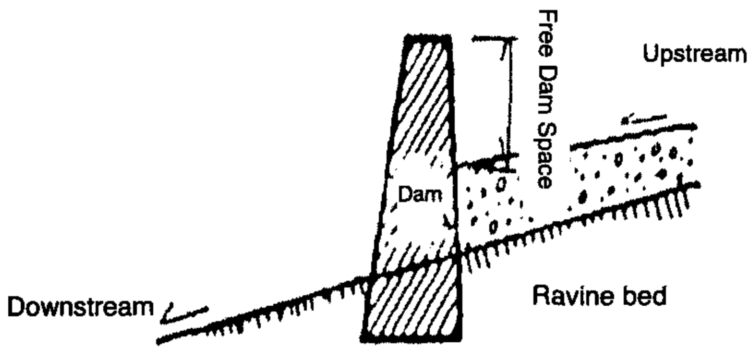


Figure 3.7.2 Dam Height and Free Dam Space Height

(3) Evaluation for Considering Road Structures

"Free space" is the height from the ravine bed to the lower part of the road structure, as shown on Figure 3.7.3.

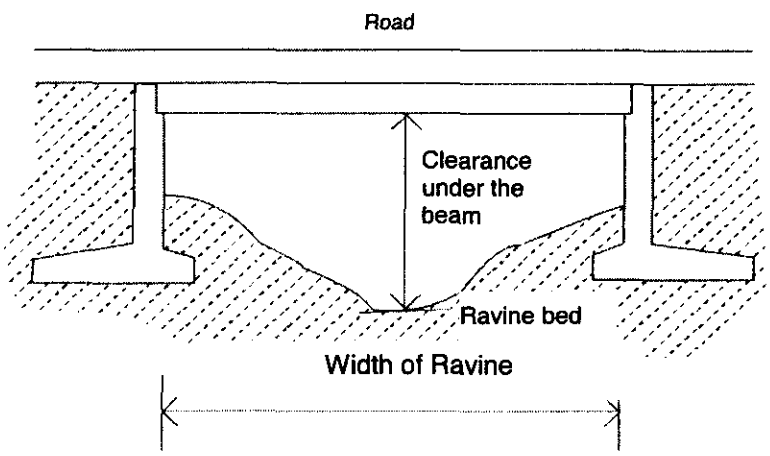


Figure 3.7.3 Free Space under the Beam and Ravine Bed Width

(4) Evaluation considering for the Disaster History

To survey the frequency of occurrence of debris flows, the survey of past disasters, the following items should be done to checked;

i) An interview for local citizen
ii) Records
iii) Vegetation (age of trees)
iv) Topography, study of the surface soil
v) Aerial photographs

(5) Scale of Prospective Damages

The damages supposed to be occurred by the debris flow should be classified in two types. The first type is the loss of embankment, and the second is the accumulation of sediments in the road.

3.7.3 Record to Stability Inspection Table and Guidelines

The results of the inspection of each site should be recorded on a "Stability Inspection Table" and attach photographs or drawings to the table.

Table 3.7.2 Record by Inspection Site

Format-3-1

No.			Inspection Item		Name of the road			Kilometer post (of)		(to)		From Managua / To			Total m.
Clasification	Toll / Common	Category		Name of the site				Site mark		Latitude			Longitude		
Traffic Restriction	Yes (Crossing/Special) Not		Restriction Criteria		Traffic Volume	Day of the week		Holliday		DID	Yes No	Bus Route	Yes No	Detour	Yes Not

Pictures of the site, Sketch (to indicate the location of the existimg works and the site mark)	Location map (scale 1/50,000)

Special remarks: Inspection Date: / / (Weather: clear・cloudy・rain) Method of inspection: Note:		
	Disasters history	Yes (1. See damage record, 2. unknow details:) Not
	Other inspection objectives	Exist or Not Rock fall, collapse, rock mass collapse, land slide, debris flow, embakment, retention wall, bridge, others
	Inspection result of year	Score: (Completed・In execution・Not started) Countermeasure:
	Inspection result of 2002 year	Score: Integral evaluation: 1. It's necesary to take measures: 2. Response, making prescription of prevention: 3. It's not necesary to take measures:
	Forecast of disasters dimension	
	Proposal countermeasures	Kind of work: Norm: Quantity: Preliminary cost:
	Stability in case of seism (for rock fall & collapse only): stable / unestable	

Table 3.7.3 Stability Investigation Table

Form 4-4

Stability Investigation Table (Debris Flow)

Inspector's Name	
Organization	

[Factor] (A)

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

[Countermeasures] (B)

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

[Road Structure] C)=(B)+α

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

[History] (D)

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

(E)=MAX(C,D)

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

[Total Evaluationl]

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

[Types of supposed damages]

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

Check with a circle the type that corresponds

Table 3.7.4 Record of the History of Damages

Form - 5-1

No.		Type of disaster		Site	Kilometer post (of)	(to)	From Managua/ To	
Inspection Site Year	Respond / Not Respond				East longitude		North Latitude	

Plane (Damages, Measures)	Seccion (Damages, Measures)

Pictures, Sketch of actual situation	Remarks	
	Date of disasters	
	Dimension	Wide, Long, Depth (m) m, m, m
	Inciding factor	Precipitation: Continue mm/ hr-d Maximum m Earth quake: Magnitude
	Damages	Human damages: deads Injuries: Material damages: Total cost of damages loss: Comments:
	Traffic restriction record	1.Full restriction: hours 2. One way road restriction: hours. 3. Others:
	Countermeasure	Year of construction: Type of works: Approximate Cost: