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Ministry of Transport and Roads

Of Kyrgyz Republic

INSPECTION AND EVALUATION MANUAL FOR ROAD DISASTER PREVENTION

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CHAPTER 1 INTRODUCTION

1.1 General

The movement of goods and passengers is 95% dependent on traffic. The network of roads with a length of about 34,000 km within the country is an important part of economic infrastructure and communication with the border states. The Kyrgyz Republic is a mountainous country, about 90% of country's territory is located at an altitude of 1000 m above sea level, about 40% at an altitude of 3000 m. Most of the roads pass through mountainous areas, therefore rockfalls, landslides and avalanches often occur. These natural disasters cause human and material losses, the closure of roads causes isolation of the region and delayed freight and passenger traffic.

The occurrence of road disasters leads not only to human casualties and damage to state property, but also has significant adverse impact on the region's logistics and social life during lengthy rehabilitation works. Thus, it is necessary to pre-install structures against road disasters in the appropriate area where a natural disaster may occur. And in order to minimize damage after a disaster has occurred, it is necessary to take appropriate measures.

1.2 Outline of Road Disaster Prevention Management System in Kyrgyz

The outline of road disaster prevention management system in Kyrgyzstan is shown in the figure below. In this regard, MOTR prepared these manuals concerning road disaster prevention in collaboration with JICA.

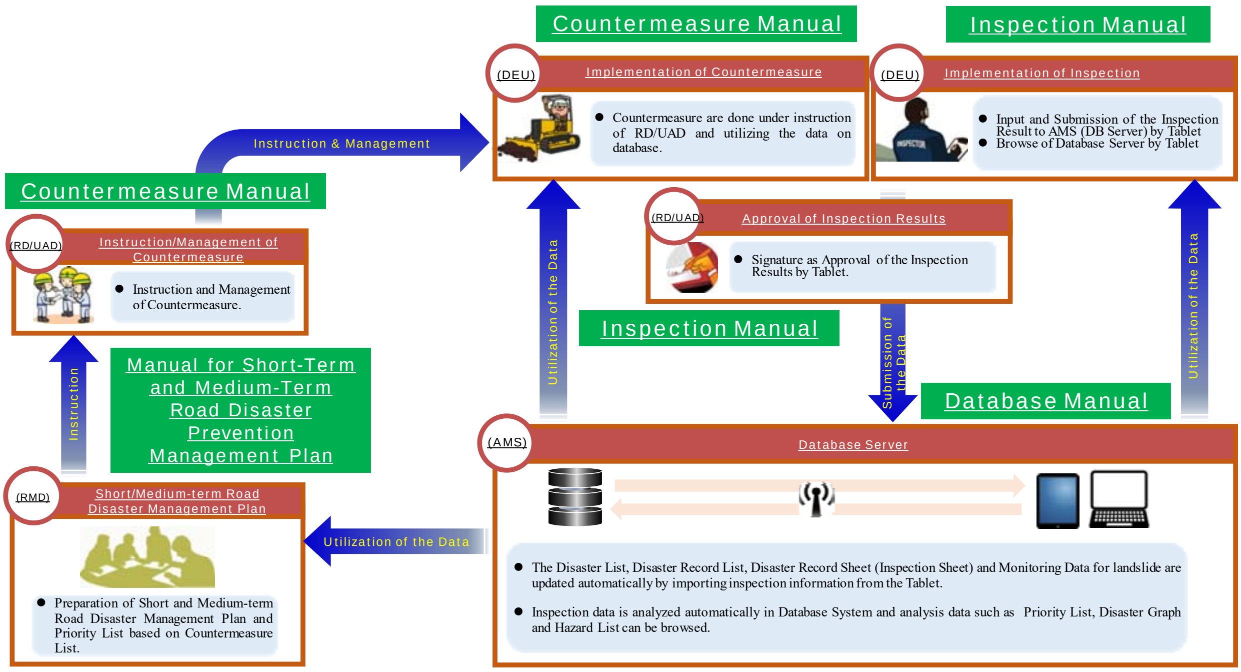


Figure 1.2.1 Outline of Road Disaster Prevention Management System

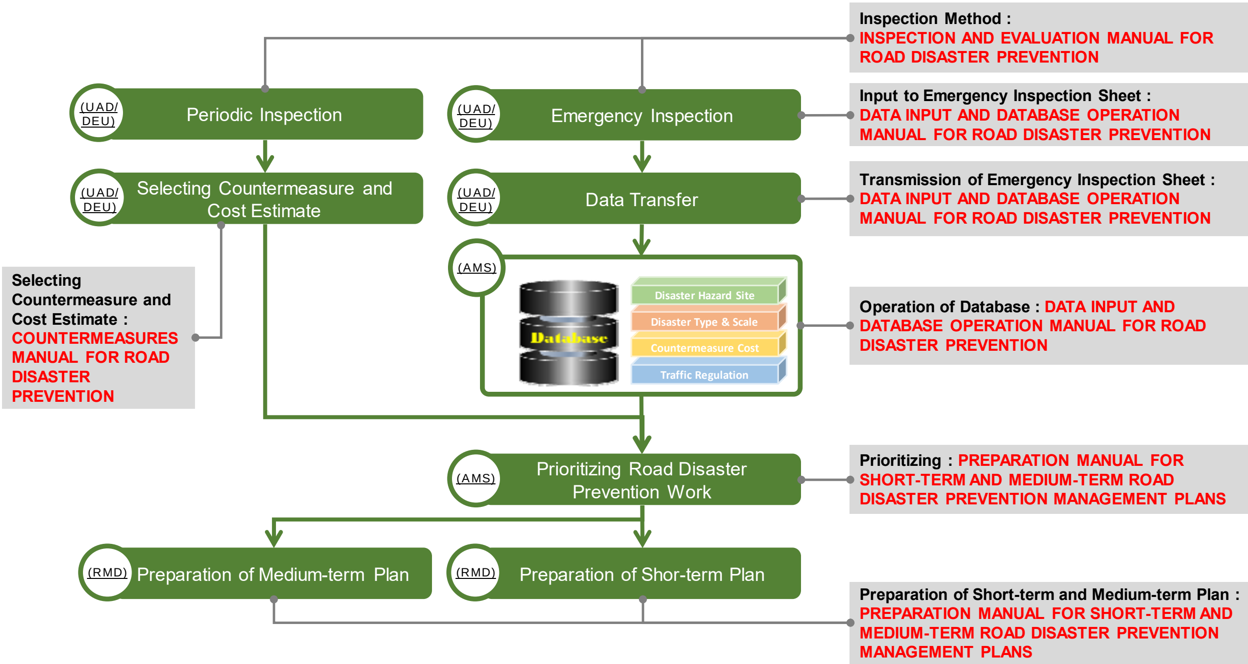


Figure 1.2.2 Flowchart of Preparation of Road Disaster Prevention Management Plan

The above "Inspection Manual" covers this manual, and it mainly describes the form of disaster occurrence.

CHAPTER 2 TYPE OF ROAD DISASTERS

2.1 Classification and Type of Occurrence of Road Disasters

The classification of road disaster in this manual is as itemized below.

- Rockfall
- Landslide
- Collapse of upstream and downstream slopes
- Debris Flow
- Erosion of bottomland area of river
- Avalanche
- Snowdrift

The types of occurrence of road disasters are as presented the following paragraphs.

2.1.1 Rockfall

Rockfall is a phenomenon where rocks and gravel represent dispersive and fractured soil, due to enlarged cracks (caused by joints, foliation and stratification developed in the bedrock) in the bedrock or outcropped rocks, boulders and gravel originally contained in talus material, pyroclastic material or a gravel bed with low degree of compaction start to fall down a slope.

There are many hazardous locations of rockfall in Kyrgyz since most of main roads run through mountainous areas. Besides, the scale of rockfall disaster in Kyrgyz is quite large.

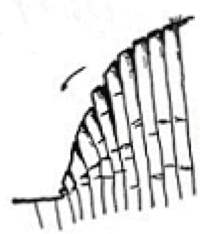
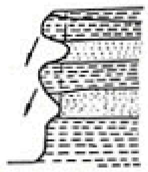
Blocked Vehicular Traffic due to Rockfall (DEP30)

Accumulated Rocks at Back of Wall (DEU-9)

The types of occurrence of rockfall are as presented the followings.

Table 2.1.1 Types of Occurrence of Rockfall

Category	Description	Schematic Drawing	Typical Geological Features	Remarks
(1) Uprooting Type	1) Dropping of gravel located on a sandy slope containing gravel		Terrace and pyroclastic material, etc.	
	2) Sliding down of gravel contained in the sediment above the bedrock		Heavily weathered rock on talus, colluvial soil, hillside slope or cut slope	Loose stone type rockfall may occur depending on the relative positions of the bedrock and sediment.
(2) Flaking Type	1) Exfoliation along the surface of discontinuity in the bedrock		Bedrock with many cracks or continual cracks	Different forms, such as sliding, falling over and falling, take place depending on the directions of the slope and cracks; special attention is required in regard to the degree of looseness.

Category	Description	Schematic Drawing	Typical Geological Features	Remarks
	2) Exfoliation of the surface of a highly weatherable or erodsible bedrock	 	Weatherable soft rock or alternation of soft and hard rock layers from the Neogene onwards	The scale is generally small but the falling of large rocks may occur at an overhang section of alternated soft and hard rock layers.
(3) Others	1) Increased instability of residual boulders, etc. on a ridge due to weathering or erosion		Weathered granite, etc.	Not frequent but tends to be on a large scale.

2.1.2 Landslide

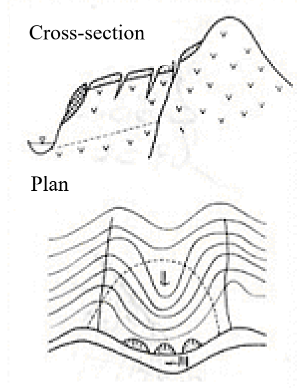
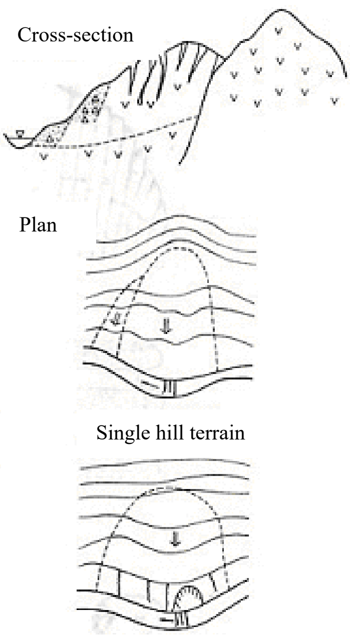
A landslide is a phenomenon where the soil mass above a boundary deep in the ground gradually shifts downward due to groundwater rising and imbalance of soil mass. Horseshoe shaped or arc shaped head cliff is formed at the top of landslide. Likewise, heave or prominence is occurred at the bottom of landslide. Hence, a lot of landslide are recognizable by topographic map or aerophotography. Landslide is characterized by occurrence condition like terrain, topography and groundwater.

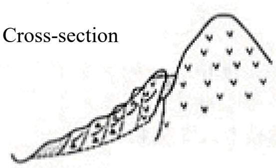
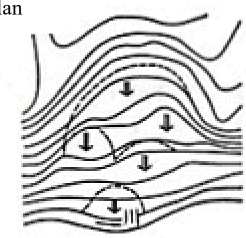
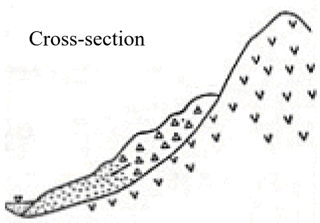
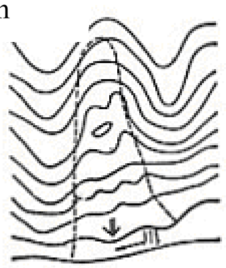
Deformed roadway due to landslide (DEU-9)

Head cliff due to Landslide (DEU-959)

The types of occurrence of landslide are as presented the followings.

Table 2.1.2 Types of Occurrence of Landslide

Category	Description	Schematic Drawing	Typical Geological Features	Remarks
(1) Bedrock Landslide	1) Convex ridge terrain with a chair or boat-type sliding surface; often starts at a saddle section 2) Bedrock or lightly weathered at the head and weathered rock at the bottom 3) Sudden occurrence makes its prediction very difficult; careful reconnaissance and a detailed survey are required	 Convex ridge terrain	Often affected by a fault or fracture zone; Tertiary formations, crystalline schist and Mesozoic and Paleozoic formations	Triggered by large-scale earthworks, submersion of part of the slope, earthquake or heavy rain
(2) Weathered Rock Landslide	1) Convex plateau terrain, single hill, concave plateau terrain with a chair or boat-type sliding surface 2) Weathered rock with many cracks at the head and sediment mixed with boulders at the bottom	 Single hill terrain Concave plateau	Crystalline schist, Mesozoic/Paleozoic formations or Neogene formation affected by a fault or fracture zone	Triggered by a downpour, abnormal thawing, earthquake or medium-scale earthworks

Category	Description	Schematic Drawing	Typical Geological Features	Remarks
(3) Colluvial Deposit Landslide	1) Multiple hill or concave plateau terrain with a stair or layer-type sliding surface which can be divided into 2 – 3 blocks 2) Mainly consists of sediment containing gravel and becomes clay at the bottom 3) Intermittent activity repeated every 5 – 20 years; landslide hysteresis is clear from the topographical point of view and can be checked with a topographical map of 1 to 5,000 or 1 to 10,000; interviews with local people are also useful	Cross-section  Plan  Multiple hill terrain	Colluvial deposit from crystalline schist, Mesozoic/Paleozoic formations, Neogene formation or serpentinite	Triggered by thawing, typhoon, downpour or medium-scale earthworks
(4) Clayey Soil Landslide	1) Gently sloping concave terrain with a multi-blocked stair or layer type sliding surface; closer relation between the blocks than (3) 2) Mainly consists of clay or clay containing gravel 3) As landslide movement is semi-continuous with a recurrence every 1 -5 years, its presence is well-known locally.	Cross-section  Plan  Gently sloping concave	Neogene formation, fracture zone and solfataric soil	Easily activated by a downpour, thawing, river erosion or small-scale earthworks

2.1.3 Collapse of Upstream Slope

A slope collapse is a phenomenon where the surface soil/rock above a boundary in the ground shifts downward. Slope collapse is occurred by a rainfall or denudation although the slope is stable at normal condition. Slope collapse due to heavy rain tend to occur in the following condition.

1) Steep slope (Steeper than 30 degree)
2) Slope which has knick point (There is sharp change on slope)
3) Concave slope,
4) Slope which has gentle slope at the upper portion

3), 4) are easily formed a pool.

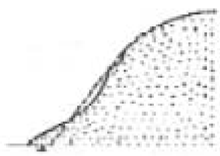
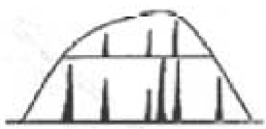
Slope Collapse from Road Shoulder to Lower (DEU-30)

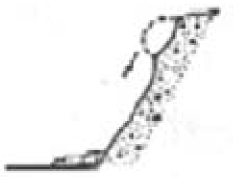
Slope Collapse on Cut Slope (BNT Road)

There are many Talus which is accumulated by continuous slope collapse and weathered rock in Kyrgyz. Some source of accumulated talus is from 200 m in height above road surface. The accumulated talus is stable gradient from 30 to 35 degree. However, the increasing accumulated talus might cause a traffic disturbance and a large scale of road disaster. The accumulated talus might be a pathway for a rockfall.

The types of occurrence of slope collapse are as presented the followings.

Table 2.1.3 Types of Occurrence of Slope Collapse

Category	Description	Schematic Drawing	Typical Geological Features	Remarks
(1) Erosion, collapse	1) Dry and wet cycle, Slaking, Rainfall will cause gully erosion. Sometimes it will be develop to deep collapse.	 	Volcanic ash soil Disintegrated granite Fine sand Tuff(Tertiary) Weathering slate Top soil	Cutting slope Poor vegetation work

Category	Description	Schematic Drawing	Typical Geological Features	Remarks
	2) Overhung		Volcanic clastic material Terrace deposit(sand and gravel) Colluvial deposit	Cutting slope which lose the lower part
(2) Weathering rocks and layer	Surface of the rocks will be collapsed by weathering.		Mud stone Tuff Weathering slate Schist Terranolite	Cutting slope is tend to weathering faster

2.1.4 Debris Flow

A debris flow is a phenomenon in which soil at the bottom of a valley or upstream moves because of heavy rain, melting snow or earthquake and flows in hydraulic bores out of the valley. The occurrence of debris flow simultaneously requires three elements, such as steep slope, enough water and movable soil. The most of debris flow occurs on the slope which gradient is steeper than 15 degree. The most of debris flow stops and accumulates on the slope which gradient is from 2 to 10 degree. However, the fine sand comes down to the section of gentle slope.

	
DEU-50: Sedimentation of debris flow on the road	DEU-959: Sedimentation of debris flow on the road

Figure 2.1.1 Example of Debris Flow Disaster on Road

The types of occurrence of debris flow are as presented the followings. The outline is as shown in Figure 2.1.2.

2.1.4.1 Debris Flow Caused by Fluidization of Sediment on Streambed

Sediment on the steep streambed is fluidized by intense rainfall and melting snow.

2.1.4.2 Debris Flow Caused by Sediment of Hillside Collapse

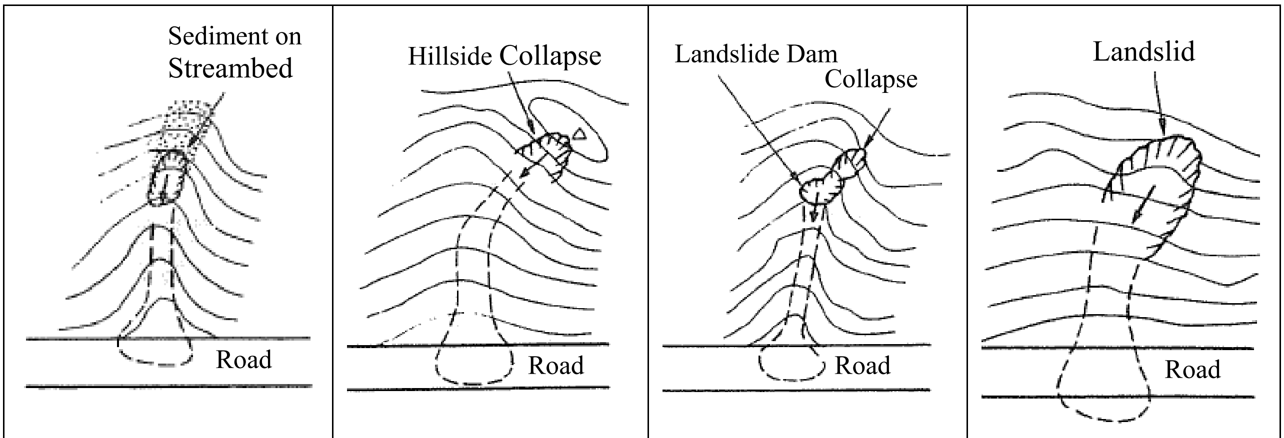
Soil of hillside collapse is fluidized by mixed with water. It is hard to distinguish this type of occurrence of debris flow from slope collapse.

2.1.4.3 Debris Flow Caused by Collapse of Landslide Dam

Landslide dam is generated by temporary suspension of stream flow due to landslide. The erosion due to overflow or landslide dam break causes the debris flow.

2.1.4.4 Debris Flow Caused by Fluidization of Soil Mass of Landslide

The clod of landslide with high moisture content mainly fluidizes and becomes debris flow.



Fluidization of Sediment on Streambed | Sediment of Hillside Collapse | Collapse of Landslide Dam | Fluidization of Soil Mass of Landslide

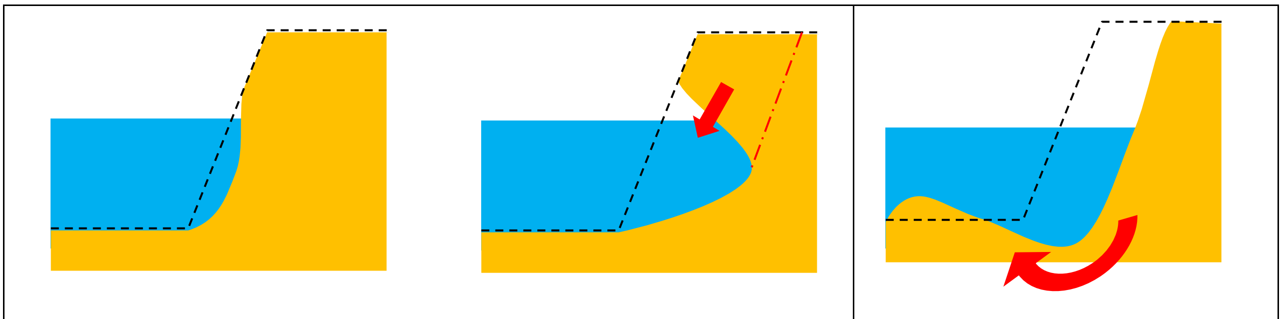
Figure 2.1.2 Type of Debris Flow Disaster Occurrence

2.1.5 Erosion of Bottomland Area of River

The scale and shape of riverbank erosion depends on the river configuration, slope material terrain, type/condition of vegetation, situation of infiltration flow and discharge variation.

The cause of riverbank erosion has two following mechanisms.

- Fluvial/Hydraulic erosion process, Toe erosion process due to scouring force of river flow
- Slope/Mass failure process due to bank stability (caused by additional embankment, or riverbed scouring, etc.)



Fluvial/Hydraulic erosion process, Toe erosion process | Slope/Mass failure process

Figure 2.1.3 Type of Riverbank Erosion Disaster Occurrence

Even though revetment is installed, the revetment will be collapse due to inadequate structure/material. The sample of damaged/collapsed revetment is as shown in Figure 2.1.4

		
Collapsed due to riverbed erosion at foundation of revetment (inadequate foot protection)	Washed out slope protection due to inadequate size/weight of block	Collapsed due to coming out of fine materials underneath the revetment (inadequate filter cloth)

Figure 2.1.4 Sample of Damaged/Collapsed Revetment

2.1.6 Avalanche

An avalanche is a natural phenomenon in which the snow accumulated on the mountain slope under the action of gravity comes down the slope and lasts from several seconds to 1 to 2 minutes. An avalanche is categorized as follows based on the form of occurrence etc.

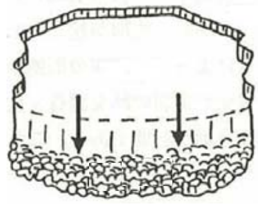
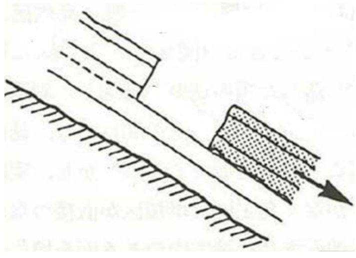
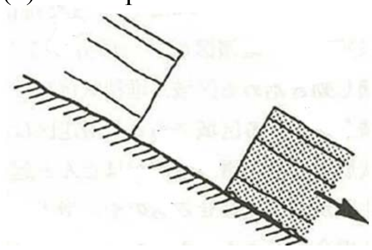
Form of occurrence	(1) Point occurrence avalanche  ➢ Wedge shaped ➢ Generally small scale	(2) Planar avalanche  ➢ It starts to move all together over a fairly wide area ➢ Generally large scale
Slide surface position	(1) Surface avalanche  Slide surface is inside the snow cover ➢ Generally occurred in winter	(2) Full depth avalanche  Slip surface is ground ➢ Generally occurred during snow melting season
Snow quality of the avalanche layer	(1) Dry snow The avalanche layer (starting snow cover) doesn't contain moisture	(2) Wet snow The avalanche layer (starting snow cover) contains moisture

Figure 2.1.5 Classification of avalanches (Source: Course on the basics of studying snow and ice Ⅲ, Avalanche and Snowdrift)

 Avalanche trace on 126 km of BO road	 Split surface in the upper part of the slope at the 121-km of Bishkek-Osh road
 A small avalanche in the road (near 123 km of BO road)	 Artificial avalanche release

Figure 2.1.6 Avalanches on Bishkek-Osh road

2.1.6.1 Avalanche generation mechanism

An avalanche occurs when the gravity exceeds mass of snow cover over the adhesive force. Since the snow cover layer is directly affected by changes such as weather (atmospheric condition) and heat transfer from the surface of the earth, physical properties (density, hardness, snow particle shape) change rapidly in a short time. This is called metamorphosis. Therefore, snow cover stability violently changes in a short time. The snow on the slope is normally affected by gravity as shown in Figure 2.1.7, and slowly moving and deforming due to glide and creep. However, in a situation where a surface avalanche occurs, a slip surface is formed due to a change in weather conditions such as snowfall and change in temperature, some sort of trigger collapses the balance between the adhesive force and the driving force, resulting in avalanche.

Main factors of increase in driving force and decrease in resistance force are as follows.

- Increase of driving force: increase in snow cover due to snowfall etc.
- Decrease of adhesive force: Changes in internal structure (snow quality) of snow, melting of snow due to rising temperature, rain etc.

Figure 2.1.7 (on the left side) shows the driving force and resistance force of snow cover, as shown as diagram in Figure 2.1.7 (on the right side). After the snowfall, the snow cover layer transforms and stabilizes after a time (old snow). If there is snowfall (fresh snow) on the stabilized snow cover, and there is a weak layer between old snow and fresh snow, avalanche occurs with the weak layer as a sliding surface. Form factors of the weak layer are as shown in Table 2.1.4, (Source: Course on the basics of studying snow and ice Ⅲ, Avalanche and Snowdrift)

Figure 2.1.8, and they are diverse. Therefore, in order to know whether a weak layer was formed or not, sample acquisition of snow cover and sample's physical and mechanical properties survey is necessary.

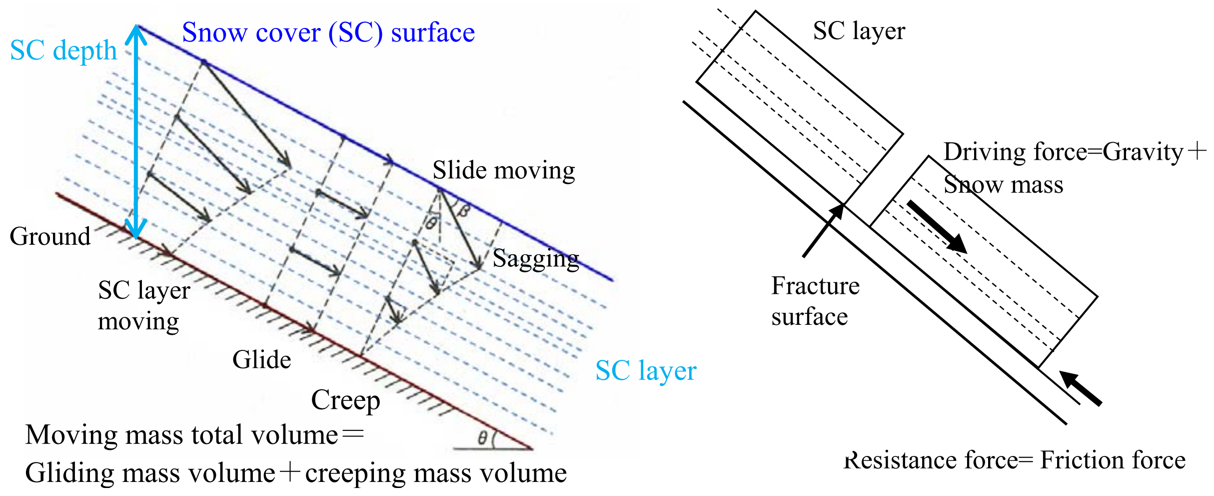
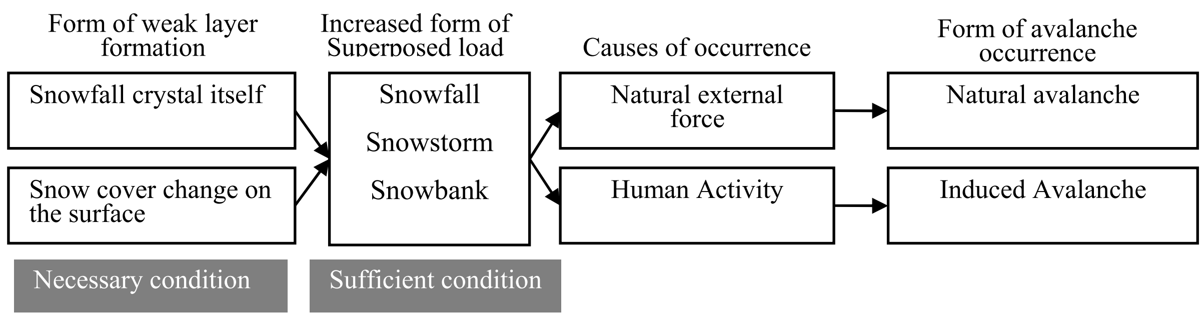


Figure 2.1.7 Glide and creep of slope snow cover and rupture of snow cover

Table 2.1.4 Periods of formation and changes in the structure of the snow cover layer and natural factors

Period	Beginning period (during snowfall)	Second period (on the surface)	End period (After burying)
Environmental factors	Crystal form (presence / absence of clouds, shape, size), temperature, wind speed	Long wavelength radiation, temperature, short wavelength radiation, wind speed	Overhead snow layer, snow temperature, temperature gradient, water supply
Structural factor	Initial structure (filling degree, density, combined structure)	Melting, Freezing, redeposition, scraping, sublimation evaporation · condensation	Consolidation, sintering, melting, freezing, sublimation evaporation · condensation
Feature	A wide variety of layer structures (Thickness from several mm to several cm)	Rapid change near the surface	Slow change (several days), decrease in number of layers



(Source: Course on the basics of studying snow and ice Ⅲ, Avalanche and Snowdrift)

Figure 2.1.8 Avalanche occurrence flowchart

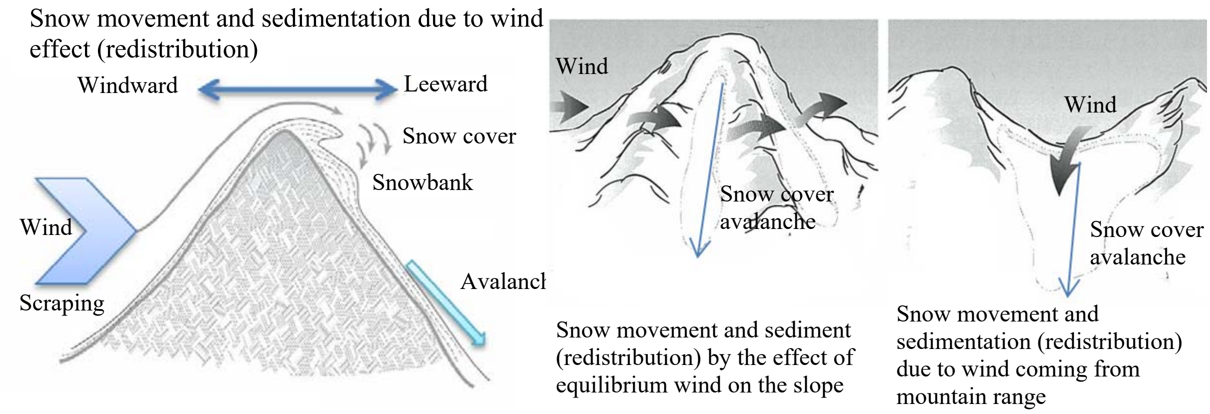


Figure 2.1.9 Causes of avalanche occurrence (Source: Avalanche risk management)

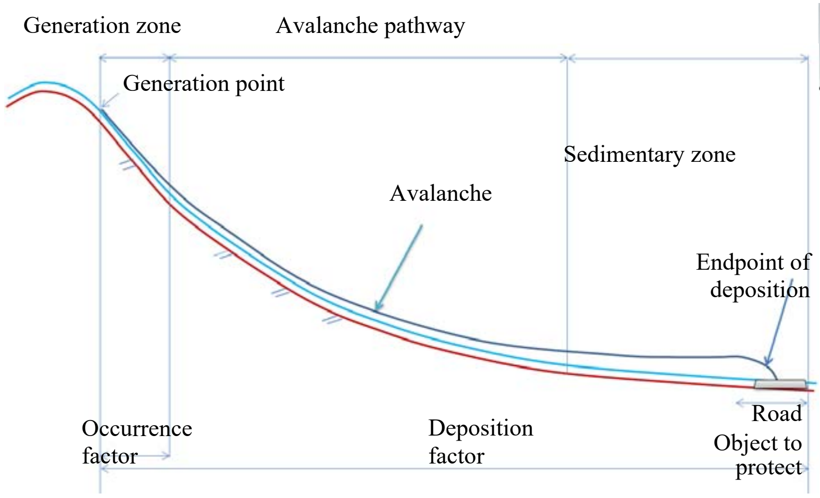
Also, weak layers may be formed by micro topography such as uneven topography, so it is impossible to know precisely where the weak layer is formed. On the other hand, snowfall, which is the cause of driving force, is affected by wind and topography, so snow cover depends on them.

A full depth avalanche is a phenomenon in which the entire layer of snow cover falls off starting from the surface of the ground. Such avalanches are usually formed due to the sliding of snow cover from the land surface. Figure 2.1.10 shows cracks, humps, snow wrinkles that appear as a precursor to the full layer avalanche.

Figure 2.1.10 Precursory phenomenon of full-layer avalanche (Source: Course on the basics of studying snow and ice Ⅲ, Avalanche and Snowdrift)

2.1.6.2 Avalanche occurrence and zone of deposition

The avalanche route is divided into a generation zone, avalanche pathway, and a sedimentary zone as shown in Figure 2.1.11, but the boundaries between them are not clear. Also, the maximum reachable distance is empirically set as Figure 2.1.13.



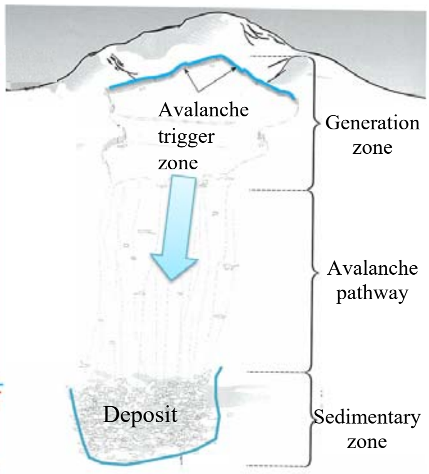


Figure 2.1.11 Section of Sediment Movement
(Right figure; modified avalanche risk management)

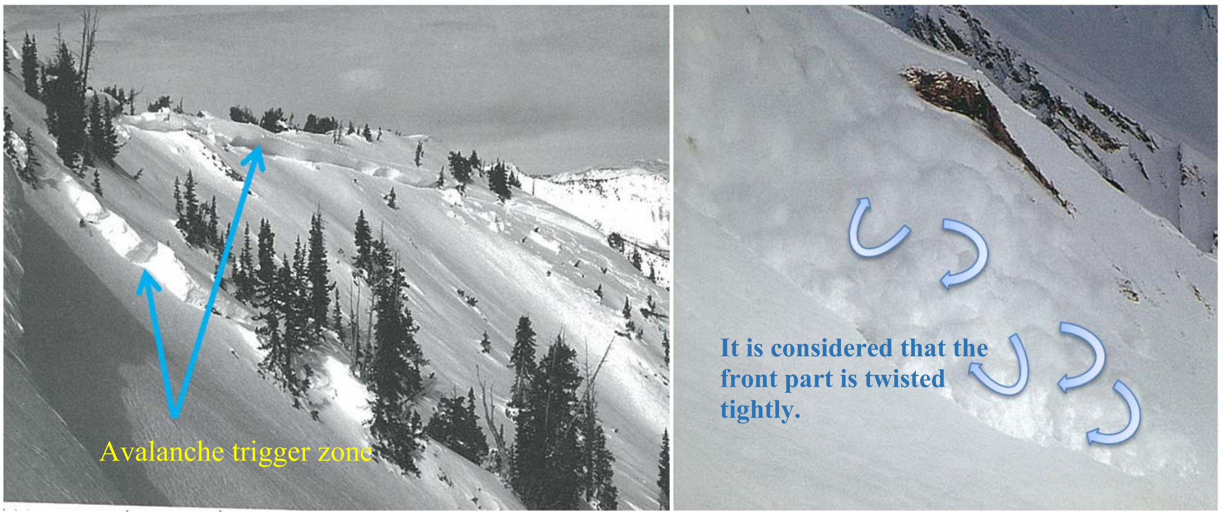
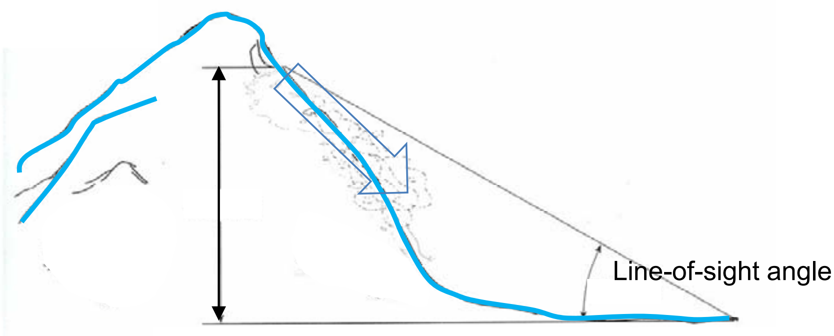


Figure 2.1.12 Avalanche occurrence area and flow front
(Source: Left, Avalanche Risk Management, Categories, Right: AVALANCHE!)



Surface layer avalanche: maximum about 18°, full layer avalanche: maximum about 24°
(Source: Avalanche risk management)

Figure 2.1.13 Rough calculation of the maximum avalanche distance, based on practical rules (Line-of-sight angle)

Actually, the reachable distance is not determined only by the line of sight, but the maximum reachable distance of the avalanche depends on the avalanche occurrence position, scale and terrain as shown in Figure 2.1.14.

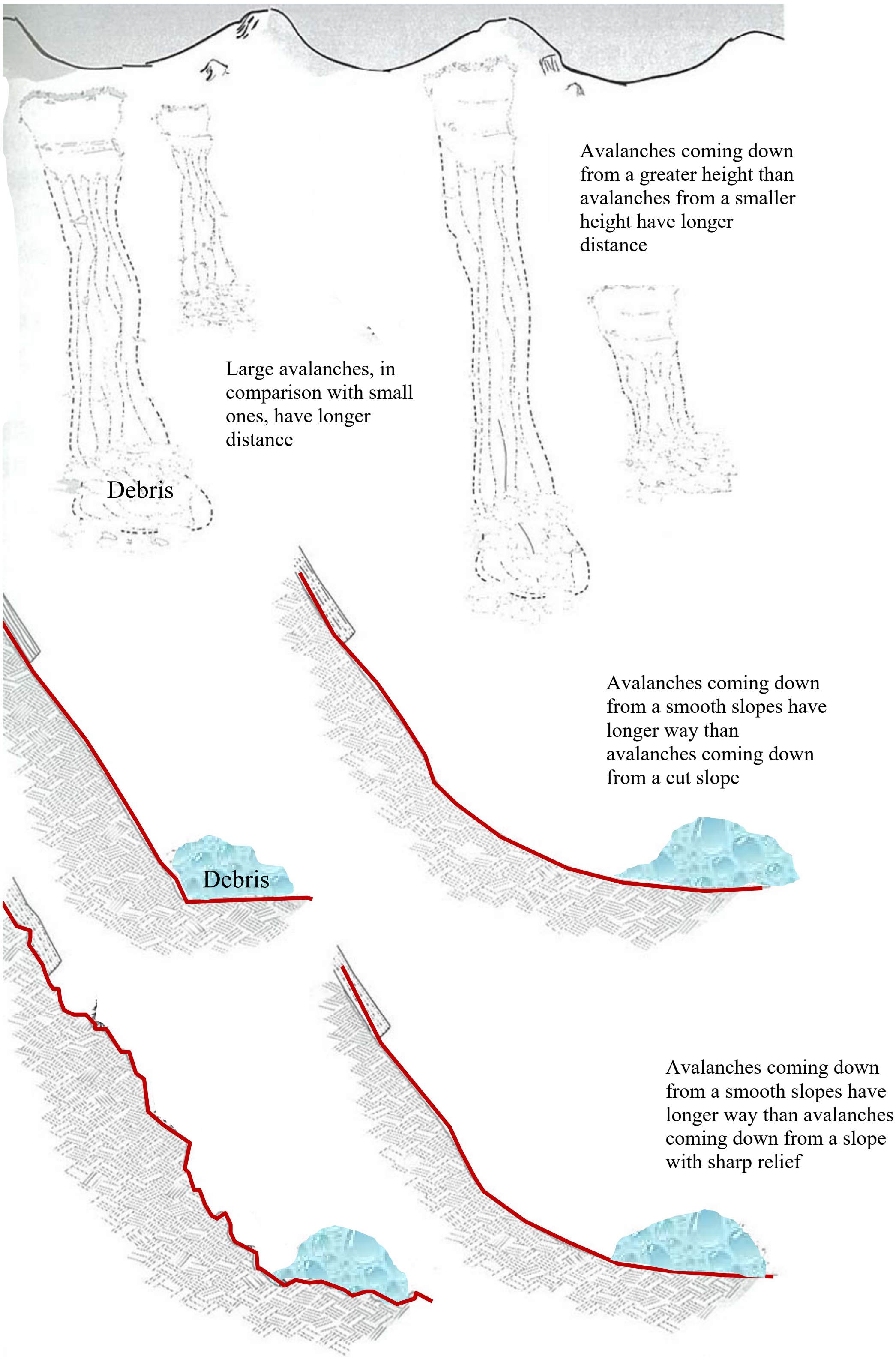


Figure 2.1.14 Avalanche pathway distance determination factors (Source: Avalanche risk management)

2.1.6.3 Features of avalanches in Kyrgyzstan

In the Kyrgyz Republic there are avalanches from dry snow caused by heavy snowfalls, as well as avalanches from wet snow due to rains in April. It is believed that these avalanches, being surface avalanches, are subdivided into various types of formation factors: a factor of heavy snowfall, a factor of loose snow, and also an icing factor.

Among the frost-shaped avalanche, there is not much snow in the target site, it is cold and sunshine, so the temperature gradient in the snow layer becomes large, so that the adhesion between the particles is small and even the snow coarsens. Rainy rough snow is easily collapsed by external factors such as rainfall, so it is considered to be a cause of avalanche in the target area. This avalanche has a danger of occurring even if there is not much snow depth. In years with heavy snowfalls, it is necessary to be careful of avalanches because of this, and in little snowy years because of a loose layer of snow and icing.

Table 2.1.5 Main causes and outline of surface avalanches

Classification		Outline
Weak layer type	New snow type	Hexagonal snow crystals with a wide surface without roughness in the windless time lie horizontally and become slippery.
	Frost form	There are coarse-grained, fine-grained and surface-icy types. However, they are all loose and have weak grip.
	Hailstone	Over time, the hailstones are not grouped and how the balls rotate easily, which is why the surface snow cover easily slides over them.
Type of heavy snowfall		With a large amount of accumulation of new snow (in case of snowfall) in a short time, the snow cover lying before the snowfall (old snow) serves as a slippery slide, in which new snow comes off at once.

Shaded places - the most likely formation reasons in the Kyrgyz Republic

The avalanche that occurred on the BO road in the past has occurred on the slope where the slope is large and the line of sight is 20 to 25 °, which is colored green to yellow in the lower figure. Along with places where avalanche occurred in the past, it can be said that there is a danger of avalanches on similar slopes.

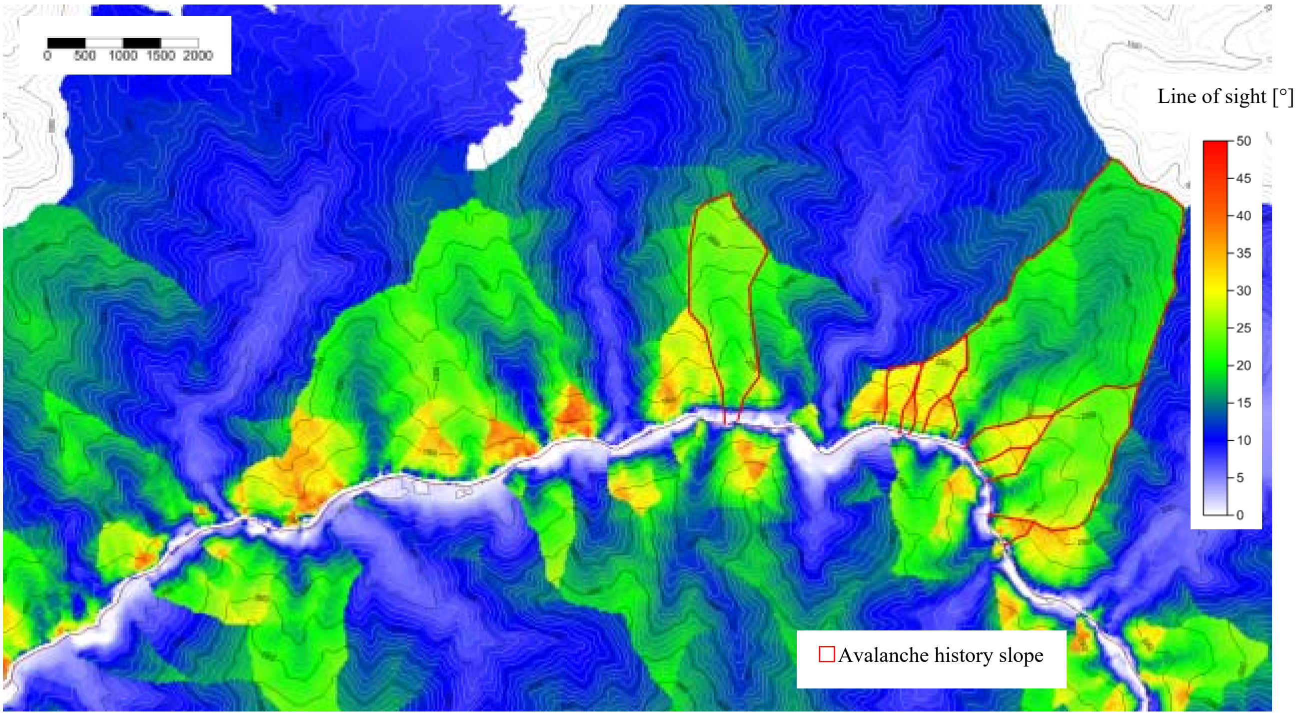


Figure 2.1.15 Line of sight distribution from BO road (DEU 23)

2.1.7 Snowdrift

Snow drifts are a natural phenomenon, when a blizzard is formed due to strong wind, and snow particles move in the form of saltation, suspended and creeping, in which, in areas of weakening of the air flow, more snow accumulates than on the plain. It is well known that a snow cover of 10 cm on the road creates difficulties for the stable movement of passenger cars, and upon reaching 20 cm, this will become impossible. Therefore, it is necessary to carry out road maintenance (snow plow) so that the snow cover does not reach 10 cm.

Also, when strong browning snow occurs, the amount of snow particles existing in the space increases, making it difficult for human eyes to see the other side of the road. This is called Visibility Failure, comfortable and stable operation becomes difficult when the visibility is 200 m or less, and the possibility of a traffic accident increases when the visibility is less than 100 m. When the visibility is 50 m or less, it can not normally operate because it is a “white darkness” where almost no visibility can be obtained. Due to this visibility failure, a deviation from the road, a collision accident to the preceding vehicle, and a frontal collision accident with the oncoming vehicle occur。

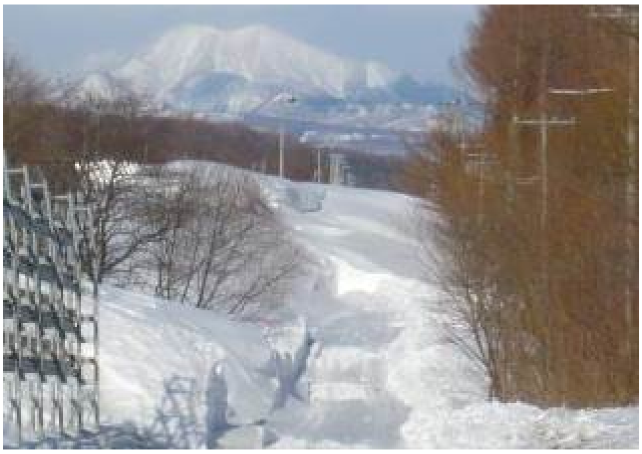


Photo A state of snowdrift on the road

Photo A state of visibility disorder

CHAPTER 3 INSPECTUON AND EVALUATION

3.1 General

The survey results need to be used to evaluate the degree of risk and priority of each site. Since the viewpoints to be noticed and the items to be investigated are different according to the type of disaster, each survey location shall be investigated according to the disaster type of the concerned place. In this chapter, investigation time, the risk assessment and monitoring method for each road disaster type will be explained.

3.2 Inspection Method of Road Disaster

3.2.1 Rockfall

In conducting a survey targeting falling rocks, it is necessary to grasp the range of falling rock origin.

In addition, it is necessary to investigate with sufficient consideration of the relationship between the distribution area of rockfall source and the route of the rockfall.

In some case, in a route passing through a steep mountainous region, the road section suffered by falling rock disaster is a short section corresponding to the exit of the valley topography equal to the route of the falling rocks. However, the source of falling rocks are large in distances and altitudes from roads and are in a large area, and observations from the road surface cannot judge the situation of falling rock origins at all. In such a case, it is necessary to conduct a detailed investigation after setting the survey scope using the topographical map covering from the road to the main ridge in advance.

Structures used for falling rock countermeasures are designed to have sufficient strength based on the impact load of falling rock and the load acting in the moving direction. Then the height and size of the unstable rock mass expected to cause damage to the road and human must be confirmed by detail inspection.

The following table shows the phase division of inspection and each point of interest.

Table 3.2.1 Outline of Inspection for Rockfall

Phase of the Inspection	Inspection purpose and contents	Time of inspection
Periodic inspection (2 times / year)	· Comparison with last time, checking traffic risk · Visual inspection from the road · Stability of target rock slope, unstable stone	Spring and Autumn （Snow melting season, rainy season opening）
Emergency inspection (Inspection after the disaster)	· Determination of measure type and scale of emergency measures · Confirm the source, surrounding the source · Check existence of more unstable rock mass behind. · Confirmation of the safety of road traffic for the time being	Target areas where falling rocks affecting road traffic (including places where rockfall occurred rapidly)
Detailed inspection	・Highly accurate risk assessment of target area · Check the sources and ranges of falling rocks that cannot be confirmed from the vicinity of the road using long time · Accurately grasp the scale and risk of disaster occurrence in the target area · Determine necessity of countermeasure work and urgency of correspondence · Utilize for periodic inspection and emergency inspection	Once in several years ·High risk of road traffic is confirming · Depending on the situation, carry out following emergency inspection and periodic inspection

3.2.1.1 Periodic inspection

Periodic inspections are to be carried out twice a year in spring and autumn (melting snow period, rainy season dawn) for all the route sections, visually checking from the road. Therefore, the time allocated per each location is short, and it is necessary to pay attention to the important inspection items so as to be an efficient check. Important inspection items are as follows.

(1) Presence of the falling rocks from the time of the previous inspection, the date and time, the scale (m 3, the road closing time), damage to human beings or vehicles

- Information exchanged at related organizations
- Falling rocks in the vicinity of the road (rocks left unattended)
- Damage traces of roads and structures

(2) Status of unstable rock mass

- Visual confirmation of stability (presence or absence of change)
- Confirm the largest falling rock mass (falling rock diameter) and falling height (altitude difference with the road)

(3) Status around the slope

- Condition of the adjacent slope (presence of fallen rock)
- Changes in water spring and vegetation
- Changes of the terrain (slope gradient, amount of sediments moved)

(4) Judgment on necessity of detailed inspection

- If accurate risk assessment has not been completed, judge that detailed investigation is necessary

Based on the above data, evaluate the risk of falling rock disaster risk.

In accordance with the evaluation results, construction priority of countermeasure construction and implementation priority of detailed investigation are determined by the road administrator.

3.2.1.2 Emergency inspection

Emergency inspections are to be carried out immediately after the falling stone disaster occurred, urgently summarize damage scale and emergency measures plan and report. Although it mainly focuses on the visual surroundings of the road and has the same attention point as the periodic inspection, it is necessary to pay attention to the following matters and organize the plan view and the cross-sectional view.

(1) Source of falling rocks

- Location of the sources of falling rock
- Relation of unstable rocks which are marked at periodical inspection

(2) Risk of secondary disaster

- Stability of the slopes after rock fall occur
- Expansion of loose and unstable areas
- Working risk of emergency measure construction

(3) Emergency measures

- Is it sufficient to remove rock masses that interfere with road traffic?

- Is there a necessity of implementing permanent measures with urgency?

(4) Cause of the rock fall

- What caused the falling rocks?
- Factors related to weather, earthquakes, heavy rain, windstorms, melting snow etc.→Rainfall refers to maximum hourly rainfall, cumulative rainfall, daily rainfall
- Artificial factors related to construction etc. (surface excavation, blasting etc)
- Factors related to road traffic (Heavy-duty vehicles and overloaded vehicles)

3.2.1.3 Detailed inspection

Detailed inspection is implemented for accurate risk assessment of falling rock danger sites. These inspections are highly required for all dangerous site. These inspections is to investigate the sources of falling rocks in the target so that they do not overlook, sufficient time and equipment are necessary for areas with wide slopes and large source area. The inspector should have sufficient investigation or practical experience about falling rock disasters or falling rock disaster survey. For details of the point of interest, inspection form, precision of results, etc., please refer to the attachment documents. However, it is necessary to consider and examine the following matters according to the result of this inspection.

1. Maximum scale of falling rocks (Shale and volume (m^3))
2. Moving route of falling rocks
3. Location and scale of Permanent measure
4. Risk for road traffic
5. Priority of measure work
6. Interval of inspection (for future)

In addition, results of detailed inspection should refer at the time of periodic inspection and emergency inspection.

3.2.2 Landslide

Regarding the landslide, the range is large and there are various cases where the positional relationship with the road is various. Even if there is a deformation near the road, it is often that it cannot be judged as a phenomenon caused by a landslide. In particular, there are many cases where rockfalls and collapse near the road occur as deformation of the end of the landslide area due to the existence of a landslide on the upper slope. Making incorrect judgment of the deformation caused by the landslide as a simple falling rock and collapse phenomenon, and construct a countermeasure work, there is a risk that it will result in a large budget loss for destroyed by full-scale activities of landslides. Therefore, it is important to understand the characteristics of the landslides and the sense of the deformation caused by the variation of the landslide, and to obtain the ability to judge the disaster type at the site. The following table shows the phase of inspection and each point of interest.

Table 3.2.2 Outline of Inspection for Landslide

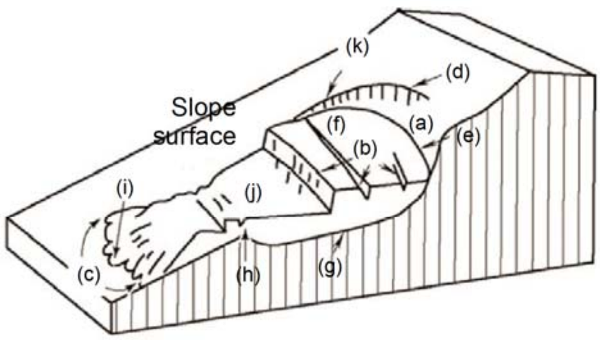
Phase of the Inspection	Inspection purpose and contents	Time of inspection
Periodic inspection (2times/year)	· Comparison with last time, checking traffic risk. · Visual inspection around the road · Check the deformation of around the landslide area	Spring and Autumn (Snow melting season, rainy season opening)
Emergency inspection (After the disaster occurred)	· Determination of measure type and scale of emergency measures · Confirm the landslide area, expansion of deformation, existence of new deformations · Confirmation of the safety of road traffic for the time being ・Hearing the information from the residents	Target areas where landslide affecting road traffic (including places where landslide occurred rapidly)
Detail inspection	· Highly accurate risk assessment of target area · Check the actual landslide area which cannot confirmed from the vicinity of the road using long time · Accurately grasp the scale and risk of disaster occurrence in the target area · Determine necessity of countermeasure work and urgency of correspondence · Utilize for periodic inspection and emergency inspection	· Once in several years · High risk of road traffic is confirming · Depending on the situation, carry out following emergency inspection and periodic inspection

3.2.2.1 Periodic inspection

When periodic inspections of landslide areas are carried out, it is sufficient to check the deformation around the road and the point of interest. The following points are set as a place suitable for the point of interests.

1. Head of the landslide (Changes of the amount of displacement of the step or crack from the last time)
2. Side of the landslide (Changes of the amount of displacement of the step or crack from the last time)
3. Foot part of the landslide (Change of compressive deformation, crack, spring water displacement amount from the previous time)
4. Deformation around the road (Collapse of cut surface, extrusion, irregularities and cracks on road surface, subsidence phenomenon of road surface, spring water, tilting / crack of structure such as retaining wall and utility pole, crack of road, deformation etc.)

If detailed inspection is not carried out, it will be checked mainly by 4. above. If deformations due to a landslide has confirmed, there is a distinctive terrain unit exist as a landslide as shown below. Investigate the site for detail and recognize the sliding area, and set the attention point.



(a) Scarp (main crack) (b) Secondary crack (c) Toe (d) Crown
(e) Top (f) Head (g) Slip surface (h) Leg (i) Tip (j) Foot
(k) Flank

Figure 3.2.1 Names of Typical Positions in a Landslide

Following sheets are format of the site inspection for 85.5 km BO-road site. There is active landslide along the BO-road and some check points of movement should be monitored continuously.

Notes for monitoring work

Frequency of monitoring are as follows

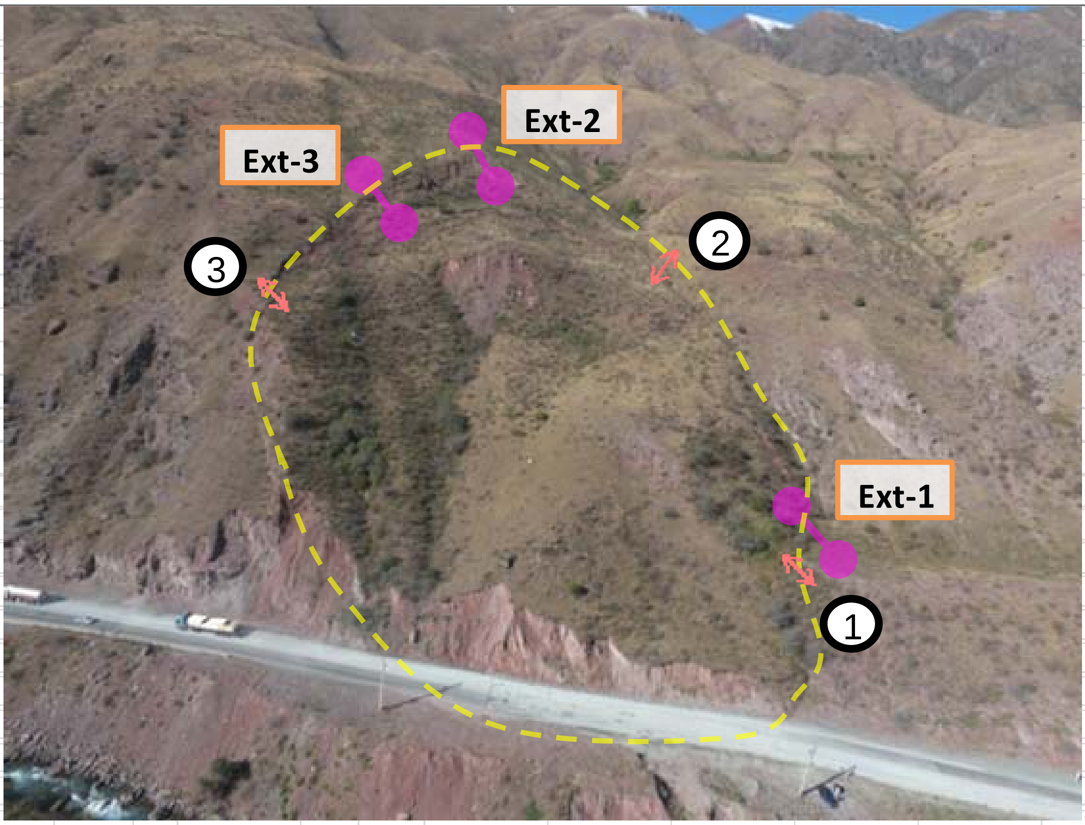
Month	Times for month	Remarks
1, 2, 3	1	If there are lot of snow, monitoring work should be canceld.
4, 5, 6	2	
7 ～ 10	1	
11, 12	1	If there are lot of snow, monitoring work should be canceld.

In the following cases, emergency monitoring work should be implemented.

1) The surface of the road suddenly deforms.

2) Slope collapse occurs around the road side.

3) Too much amount of spring water are coming from road side.



①②③ Wooden stakes

Record of periodic inspection (July to March : once per month/April to June : twice per month)

No		Disaster Type: Landslide	Route: BO-road	Location: 85.5km		
Date of the Inspection		31 D 10 M 2018 Y	D M Y	D M Y	D M Y	D M Y
1	Extensometer 1	Reading value (cm)	Reading value (cm)	Reading value (cm)	Reading value (cm)	Reading value (cm)
		14.5cm				
Difference fron last time		cm +0,5	cm	cm	cm	cm
Disaster Record						
Repair Record						
2	Extensometer 2	Reading value (cm)	Reading value (cm)	Reading value (cm)	Reading value (cm)	Reading value (cm)
		+5cm				
Difference fron last time		cm +2	cm	cm	cm	cm
Disaster Record						
Repair Record						
3	Extensometer 3	Reading value (cm)	Reading value (cm)	Reading value (cm)	Reading value (cm)	Reading value (cm)
		-8cm				
Difference fron last time		cm -1	cm	cm	cm	
Disaster Record						
Repair Record						
4	Deformatuon of road surface	Unevenness of road surface	Unevenness of road surface	Unevenness of road surface	Unevenness of road surface	Unevenness of road surface
		Uplifting and potholes are in the certain section				
Difference fron last time		same				
Disaster Record						
Repair Record						
5	Spring watetr	Spring water along the road	Spring water along the road	Spring water along the road	Spring water along the road	Spring water along the road
		Littele spring water along the road				
Difference fron last time		same				
Disaster Record						
Repair Record						
6	Discharge water	Amount of discharge water fron drilling pipe(mℓ/min)	Amount of discharge water fron drilling pipe(mℓ/min)	Amount of discharge water fron drilling pipe(mℓ/min)	Amount of discharge water fron drilling pipe(mℓ/min)	Amount of discharge water fron drilling pipe(mℓ/min)
		Not constracted yet				
Difference fron last time		mℓ/min –	mℓ/min	mℓ/min	mℓ/min	mℓ/min
Disaster Record						
Repair Record						
Remarks		Inspector (Bakyt/Nurbek)	Inspector ( )	Inspector ( )	Inspector ( )	Inspector ( )
		Weather (Cloudy)	Weather ( )	Weather ( )	Weather ( )	Weather ( )
		Almost stable				

Location of deformation			Disaster type	Landslide	
Route	BO-road	Location	85.5km	Date	31-Oct-18

Extensometer 1
Reading value is -14.5cm

Extensometer 1
No change at the surrounding area

Extensometer 2
Reading value is 5.0cm

Extensometer 2
No change at the surrounding area

Extensometer 3
Reading value is -8cm

Extensometer 3
No change at the surrounding area

Location of deformation			Disaster type	Landslide	
Route	BO-road	Location	85.5km	Date	31-Oct-18

7

Deformatuon of road surface
The starting point of uplifting at Bishkek side

8

Deformatuon of road surface
The starting point of uplifting at Osh side

9

Spring watetr along the road
Some spring water points are regognized at Osh side. The water flow amount is very little.

10

Spring watetr along the road
There are several spring water point and some has been stopped the water flow.

after the hirizontal drilling

11

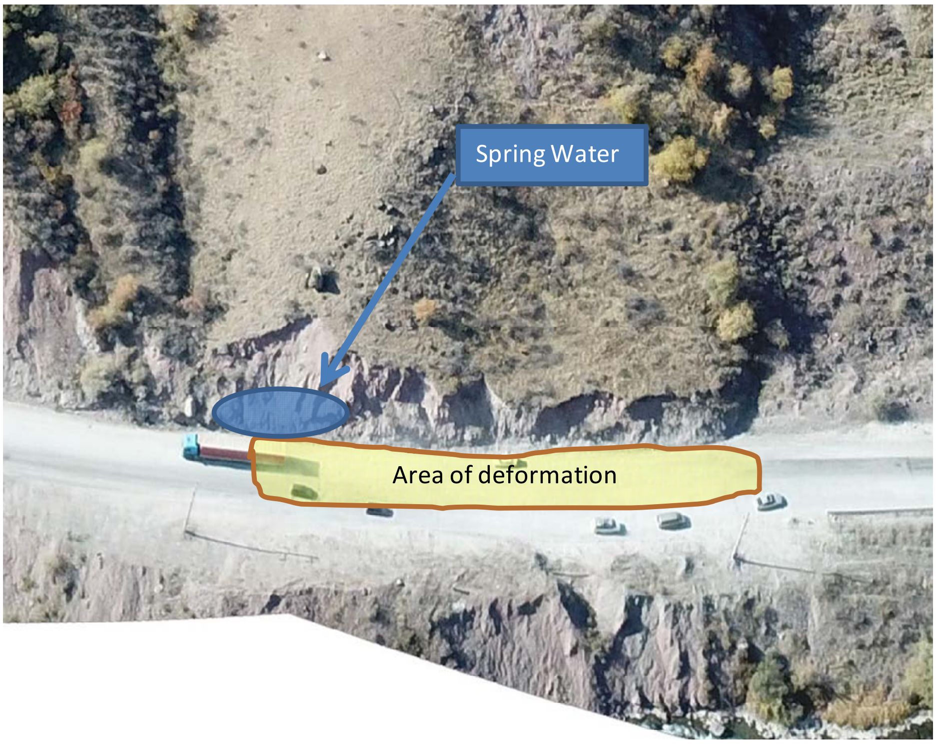
Discharge water from horizontal drilling

after the horizontal drillng

12

Discharge water from horizontal drilling

Location of deformation		Disaster type	Landslide	
Route	BO-road	Location	85.5km	Date	31-Oct-18



Deformatuon of road surface ／ Springwater along the road

after the horizontal drilling

indicate the discharge water from each pipe in the photo image

Discharge water from drilling pipe(mℓ/min)

3.2.2.2 Emergency Inspection

Emergency inspections are to be carried out immediately after the landslide disaster occurred, urgently summarize damage scale and emergency measures plan and report. Although it mainly focuses on the visual surroundings of the road and has the same attention point as the periodic inspection, it is necessary to pay attention to the following matters and organize the plan view and the cross-sectional view.

1. Landslide change region and variation form
   - Changing of landslide area
   - Which part of the landslide is there the moving mass and deformation?
   - Does the landslide area of interest focused on periodic inspection coincide with the deformation area?
   - Past history of deformation, recent situation (interviews with residents and other organizations)
2. Risk of secondary disaster
   - Continuity of landslide moving
   - Acceleration of the moving speed
   - Working risk of emergency measure construction
3. Emergency measures
   - Is it sufficient to remove sliding masses that interfere with road traffic?
   - Is there a necessity of drainage work, cutting or embankment?
   - Is there a necessity of implementing permanent measures with urgency?
4. Cause of the landslide
   - What caused the landslide
   - Factors related to weather, earthquakes, heavy rain, windstorms, melting snow etc.→Rainfall refers to maximum hourly rainfall, cumulative rainfall, daily rainfall
   - Artificial factors related to construction (cutting work, embankment etc.)

3.2.2.3 Detail inspection

Detailed inspection is implemented for accurate risk assessment of landslide sites. This inspection investigates the landslide movement area of the target area for detail, therefore sufficient time and equipment are necessary for areas with large slopes and large sources of heading. The inspector should have sufficient investigation or practical experience about landslide disasters or landslide disaster survey. For details of the point of interest, inspection form, precision of results, etc., please refer to the attachment documents. However, it is necessary to consider and examine the following matters according to the result of this inspection.

1. Moving area of landslide (width、length、specific height)
2. Direction of moving
3. Monitoring point (for periodic inspection)
4. Location and scale of temporary measures and permanent measures (Risk of acceleration of the moving speed)
5. Risk for road traffic

6. Priority of measure work
7. Interval of inspection (for future)

In addition, results of detailed inspection should refer at the time of periodic inspection and emergency inspection.

3.2.3 Slope Collapse

Slope collapse occurs on artificially modified slope as cutting or embankment and natural slope, the moving characteristics of slope collapse is deferent by soil quality by geological structure, groundwater condition and external factor as rainfall. In road disaster prevention, slope collapse is difficult disaster to predict the occurrence in advance same as falling rocks. There are characteristics that repeat disaster and It is possible to evaluate the disaster occurrence risk of the slope using the scale of the disaster occurred on the surrounding slope. Therefor it is possible to set points of interest for prior risk assessment and inspection.

The following table shows the phase of inspection and each point of interest.

Table 3.2.3 Outline of Inspection for Slope collapse

Phase of the Inspection	Inspection purpose and contents	Time of inspection
Periodic inspection （2times/year）	･ Comparison with last time, checking traffic risk ･ · Visual inspection from the road ･ · Stability of target slope ･ ・Situation of vegetation, changing	Spring and Autumn （Snow melting season, rainy season opening）
Emergency inspection （After the disaster occurred）	･ · Determination of measure type and scale of emergency measures ･ · Confirm the collapse area, expansion of deformation, existence of new deformations ･ · Confirmation of the safety of road traffic for the time being ･ ・Confirmation for function of existing retaining wall	Target areas where slope collapse affecting road traffic (including places where slope collapse occurred rapidly)
Detail inspection	･ ・Highly accurate risk assessment of target area ･ · Check the actual collapse area which cannot confirmed from the vicinity of the road using long time ･ · Accurately grasp the scale and risk of disaster occurrence in the target area ･ · Determine necessity of countermeasure work and urgency of correspondence ･ · Utilize for periodic inspection and emergency inspection	･ Once in several years ･ · High risk of road traffic is confirming ･ · Depending on the situation, carry out following emergency inspection and periodic inspection.

3.2.3.1 Periodic inspection

For periodic inspection of slope collapse, it is desirable that detailed investigation has been carried out beforehand and the point of interests has been picked up. The following points are set as a place suitable for the point of interest.

1. Head of the slope collapse（Changes of the amount of displacement of the step or crack from the last time）
2. Side of the slope collapse（Changes of the amount of displacement of the step or crack from the last time）
3. Foot part of slope collapse（Existence of new moving deposit, Change of compressive deformation, crack, spring water displacement amount from the previous time）
4. Deformation around the road（Collapse of cut surface, extrusion, irregularities and cracks on road surface, subsidence phenomenon of road surface, spring water, tilting / crack of structure such as retaining wall and utility pole, crack of road, deformation etc.）

If detailed inspection is not carried out, it will be checked mainly by 4. above. If deformations due to a landslide has confirmed, there is a distinctive terrain unit exist as a landslide as shown below. Investigate the site for detail and recognize the sliding area, and set the attention

3.2.3.2 Emergency inspection

Emergency inspections are carried out immediately after the slope collpase disaster occurred, urgently summarize damage scale and emergency measures plan and report. Although it mainly focuses on the visual surroundings of the road and has the same attention point as the periodic inspection, it is necessary to pay attention to the following matters and organize the plan view and the cross-sectional view.

1. Disaster area and characteristics of moving
   - Scale of the collapse (width, height, depth)
   - Position of the slope which collapse occurred
   - Does the collapse area of interest focused on periodic inspection coincide with the deformation area?
   - Past history of deformation, recent situation (interviews with residents and other organizations)）
2. Risk of secondary disaster
   - Possibility of extending the collapse area
   - Stability of surround area
   - Working risk of emergency measure construction
3. Emergency measures
   - Is it sufficient to remove sliding masses that interfere with road traffic
   - Necessity and possibility of drainage work, cutting slope, embankment for foot area
   - Is there a necessity of implementing permanent measures with urgency?
   - Necessity of temporary work (for keep safety traffic)

- Emergency measures

4. What caused the slope collapse

- Factors related to weather, earthquakes, heavy rain, windstorms, melting snow etc.→Rainfall refers to maximum hourly rainfall, cumulative rainfall, daily rainfall

- Artificial factors related to construction (cutting work, embankment etc.)

3.2.3.3 Detailed inspection

Detailed inspection is implemented for accurate risk assessment of slope collapse sites. These inspections are highly required for all dangerous site. These inspections is to investigate the sources of slope collapse in the target so that they do not overlook, sufficient time and equipment are necessary for areas with wide slopes and large source area. The inspector should have sufficient investigation or practical experience about slope collapse disasters or slope collapse rock disaster survey. For details of the point of interest, inspection form, precision of results, etc., please refer to the attachment documents. However, it is necessary to consider and examine the following matters according to the result of this inspection.

1. Moving area of slope collapse（width、length、depth）
2. Direction of moving
3. Monitoring point（for periodic inspection）
4. Location and scale of temporary measures and permanent measures（Risk of move repeatedly）
5. Risk for road traffic
6. Priority of measure work
7. Interval of inspection(for future)

In addition, results of detailed inspection should refer at the time of periodic inspection and emergency inspection.

3.2.4 Debris Flow

The outline of inspection for debris flow is as shown in Table 3.2..

Table 3.2.4 Outline of Inspection for Debris Flow

Type of Inspection	Description	Frequency/timing
Routine Inspection	・Visual inspection of visible areas from a road patrol vehicle ・Grasping precursory phenomenon of debris flow ・Preparation for debris flow	Daily
Periodic Inspection (Twice a year)	・Comparison with previous periodic inspection and confirmation of traffic risk ・Visual inspection of visible areas from a road patrol vehicle ・Condition of streambed/drainage facility	Spring and Autumn (After snowmelt season and after rainy season)

Type of Inspection	Description	Frequency/timing
Extraordinary Inspection (After disaster)	・ Scale of Debris Flow ・ Duration of Traffic Regulation and Cleaning (Whole Lanes and One Side Lane) ・ Number of Human/Vehicle Damage (Decease, Serious Injury, Slight Injury, Vehicle Damage) ・ Weather Condition at Occurrence (Amount of Rainfall) ・ Method of Rehabilitation	After disaster

3.2.4.1 Routine Inspection

Routine inspection involves the visual inspection of visible areas from a road patrol vehicle to detect any abnormality early. Likewise, the status of utilization of road is routinely checked.

This inspection includes to grasp the precursory phenomenon of debris flow and to prepare for the debris flow. The confirmation items of routine inspection are as shown in Table 3.2..

Table 3.2.5 Confirmation Items of Routine Inspection

Type	Confirmation Item	Remarks
Grasping precursory phenomenon of debris flow	・ Increase of sediment volume on streambed including bounding stone and driftwood ・ Detection of muddy water ・ Occurrence of slope collapse, landslide, clack on slope and formation of landslide dam at the upstream (mountain) area	The information about upstream (mountain) area is provided by the sheepherder and local resident
Preparation for debris flow	・ Obstruction at valley side, like stacked debris and wall. (Changing to slit type guardrail) ・ Sedimentation at drainage catchment basin, pipe and culvert	The obstruction shall be removed so that debris flow smoothly pass through the road or drainage pipe

The inspector/checker for the routine inspection shall inform the situation DEP, UAD/PLUAD and head office of MOTR. Based on the routine inspection result, proper action shall be taken.

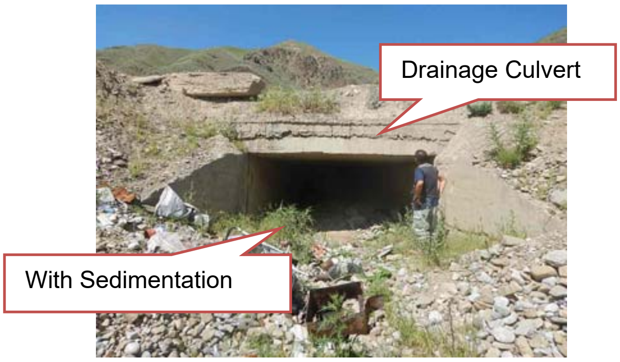
3.2.4.2 Periodic Inspection

Periodic inspection involves the detailed checking of a slope/steam by approaching the subject slope/stream. The interval of periodic inspection is relatively long like once or twice a year.

The confirmation items of periodic inspection are as given in Table 3.2.

Table 3.2.6 Confirmation Items of Periodic Inspection

Confirmation Item	Description
Stream/Spring Water from Mountain Side	The existence of water is key factor of debris flow occurrence since stream/spring water induces slope disaster including debris flow. 
Width of Stream at Mountain Side	The debris flow scale on the road is assumed by width of stream. Besides, widening and narrowing of stream width mean sedimentation and erosion of stream, respectively. Hence, it is necessary to be careful when the stream width is changed. 
Main Materials of Streambed at Mountain Side	The debris flow scale on the road is assumed by material of streambed. It is difficult to remove the large boulder on the road, and it takes a long time for recovery of traffic. It is necessary to be careful when the material of streambed is changed. 
Condition of Causeway	The followings shall be recorded during periodic inspection. ● No Causeway ● Damage at Concrete Surface ● Damage at Concrete Joint ● Sedimentation of Debris on Concrete Surface

Confirmation Item	Description
Drainage Pipe/Culvert under the Road	Debris flow passes through the drainage culvert/pipe if the adequate size of drainage facilities is installed. Likewise, the maintenance of drainage facilities like removal of sedimentation inside the culvert/pipe is required. 
Condition of Drainage at Valley Side	It is necessary to install the proper drainage facilities like ditch and flume at the valley side. There is a possibility that the slope of valley side is eroded by debris flow if proper drainage facilities are not installed. Eventually, the erosion of slope at valley affects the road structure and traffic. 

Other than those above, the photograph and comment of site condition shall be recorded. The detailed investigation or proper action shall be conducted based on the periodic inspection if necessary.

3.2.4.3 Extraordinary Inspection

Extraordinary inspection is conducted after debris flow occurred. This inspection contributes to plan and design the countermeasures. Accumulation of the extraordinary inspection date contributes to comprehend the mechanism of debris flow at the local area and to analyze the statistics data for the debris flow.

The confirmation items of extraordinary inspection are as itemized below.

- Location (Name of Road, Distance Mark)
- Occurrence Date
- Scale of Debris Flow
- Duration of Traffic Regulation and Cleaning (Whole Lanes and One Side Lane)
- Number of Human/Vehicle Damage (Decease, Serious Injury, Slight Injury, Vehicle Damage)
- Weather Condition at Occurrence (Amount of Rainfall)
- Method of Rehabilitation

3.2.5 Riverbank Erosion

The outline of inspection for riverbank erosion is as shown in Table 3.2..

Table 3.2.7 Outline of Inspection for Riverbank Erosion

Type of Inspection	Description	Frequency/timing
Routine Inspection	· Visual inspection of visible areas from a road patrol vehicle · Grasping precursory phenomenon of debris flow · Preparation for debris flow	Daily
Periodic Inspection (Twice a year)	· Comparison with previous periodic inspection and confirmation of traffic risk · Visual inspection of visible areas from a road patrol vehicle · Condition of riverbank	Spring and Autumn (After snowmelt season and after rainy season)
Extraordinary Inspection (After disaster)	· Scale of Riverbank Erosion · Duration of Traffic Regulation and Cleaning (Whole Lanes and One Side Lane) · Number of Human/Vehicle Damage (Decease, Serious Injury, Slight Injury, Vehicle Damage) · Weather Condition at Occurrence (Amount of Rainfall) · Method of Rehabilitation	After disaster

3.2.5.1 Routine Inspection

Routine inspection involves the visual inspection of visible areas from a road patrol vehicle to detect any abnormality early. Likewise, the status of utilization of road is routinely checked.

Particularly, the routine inspection during winter season is important because the bottom of riverbank and riverbed can be observed during winter season because of low water level.

The confirmation items of routine inspection are as shown in Table 3.2..

Table 3.2.8 Confirmation Items of Routine Inspection

Confirmation Item	Description
Aggravation of Riverbank Erosion	It is necessary to be careful of the distance between shoreline and road.
Damage, Deformation and Depression of River Structures	The damage, deformation and depression of river structures, such as revetment, foot protection and spur dike mean the size and material of structures are not adequate. Thus, the road will be damaged if remain untouched.
Crack or Hole on Road near Shoreline	The crack on the road near the shoreline would cause sliding failure. The hole on the road near the shoreline might have large cavity under the road due to riverbank erosion. Thus, both of this affect the road traffic if remain untouched.
Overflow from River	Overflow from river adversely affect the road structure, such as washed out road surface/bed and depression. It is necessary to install the parapet wall at river side or to heighten the road elevation.

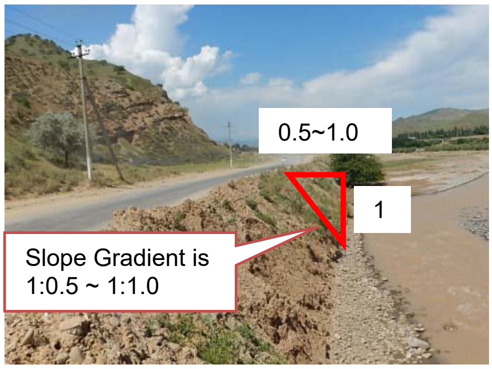
The inspector/checker for the routine inspection shall inform the situation DEP, UAD/PLUAD and head office of MOTR. Based on the routine inspection result, proper action shall be taken.

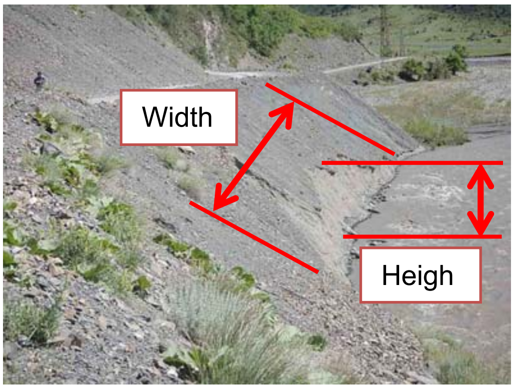
3.2.5.2 Periodic Inspection

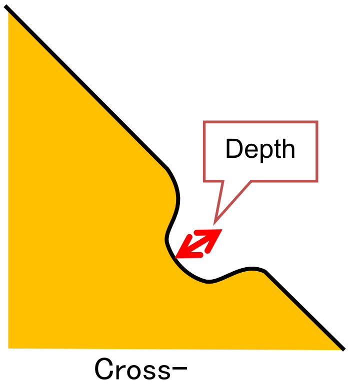
Periodic inspection involves the detailed checking of a slope/steam by approaching the subject riverbank. The interval of periodic inspection is relatively long like once or twice a year.

The confirmation items of periodic inspection are as given in Table 3.2..

Table 3.2.9 Confirmation Items of Periodic Inspection

Confirmation Item	Description
Slope Gradient	The slope gradient is key factor for stabilization of slope. The preferable slope gradient along the river is 1-vertical to 2-horizontal (1:2). 
Slope Height and Water Depth	The slope height is defined from top of slope (or road surface) to slope toe. The height becomes higher if the riverbed is eroded. 
Condition of Slope Protection	Slope protection is the most effective countermeasures against riverbank erosion. The inspector should know the condition of immediate aftermath of the construction and previous condition of the slope protection to compare with the existing condition.  

<table>
<tr><th>Confirmation Item</th><th>Description</th></tr>
<tr><td>Scale of Erosion</td><td>The inspector needs to check the scale/area of erosion comparing with the previous inspection.



</td></tr>
<tr><td>Place of Erosion on Slope</td><td>The erosion on bottom of slope might be caused by river flow. On the other hand, the erosion on top of slope might be caused by rainfall or surface water of road due to inadequate drainage system.

</td></tr>
<tr><td>Distance Between Shoreline and Road.</td><td>The distance between shoreline and road is most important factor and impact on the road traffic. The positive distance (+) means the existing shoreline is located at the river side from the edge of carriageway. Thus, the adequate road width is ensured. On the other hand, the negative distance (-) means the riverbank erosion narrows the carriageway and adversely affects the road traffic. In this instance, the countermeasures like embankment and slope protection shall be required immediately.

</td></tr>
</table>

Other than those above, the photograph and comment of site condition shall be recorded. The detailed investigation or proper action shall be conducted based on the periodic inspection if necessary.

3.2.5.3 Extraordinary Inspection

Extraordinary inspection is conducted after riverbank erosion occurred. This inspection contributes to plan and design the countermeasures. Accumulation of the extraordinary inspection date contributes to comprehend the mechanism of riverbank erosion at the local area and to analyze the statistics data for the riverbank erosion.

The confirmation items of extraordinary inspection are as itemized below.

- Location (Name of Road, Distance Mark)
- Occurrence Date
- Scale of Riverbank Erosion
- Duration of Traffic Regulation and Cleaning (Whole Lanes and One Side Lane)
- Number of Human/Vehicle Damage (Decease, Serious Injury, Slight Injury, Vehicle Damage)
- Weather Condition at Occurrence (Amount of Rainfall)
- Method of Rehabilitation

3.2.6 Avalanche

Avalanche is a phenomenon that tends to repeat, therefore, in the study of avalanches, the study of the history of avalanches is extremely important.

In countermeasure works against avalanches it is necessary to stop avalanche or reduce reaching the road, so record the occurrence / sedimentation place of the avalanche and the deposit amount and height in the vicinity of the road as information on the scale of the avalanche generated is necessary.

Inspection of avalanche areas includes a survey of cracks in the snow cover of avalanche areas, protrusions of snow cornices, the state of accumulation of snow due to snowdrifts, after that the possible threat of avalanches become clear. However, avalanches in the Kyrgyz Republic are formed on steep slopes with a huge basin area, which is why it is extremely difficult to determine the zone of avalanche generation from the road, as well as checking for avalanche precursors before its formation.

The following table shows phase division of inspection and each point of interest.

Table 3.2.10 Outline of Inspection for Avalanche

Inspection phase	Inspection purpose and content	Inspection timing
Emergency inspection (Sequential inspection)	· Inspect immediately after avalanche occurrence · Information on the location (occurrence place, arrival position) of the avalanche, information on the scale (width on the road, height, length) · Weather conditions at avalanche occurrence · Presence or absence of traffic regulation · Confirm snow removal system, Confirm the risk of secondary avalanche	· After the avalanche occurrence · Target areas where avalanches affecting road traffic occurred
Static inspection	· Confirm the avalanche location that occurred in winter and check deformations of the slope and availability of avalanche occurrence · Accurately grasp the scale and risks (frequency and damage) of disaster occurrence in the target area · Determine necessity of measures	· 1 time / year (spring) · Areas, where winter avalanches occurred

Inspection phase	Inspection purpose and content	Inspection timing
Periodic inspection (Non construction countermeasure)	・ To determine the avalanche risk in winter, the condition of snow cover is examined, as well as precursors of avalanches. · Snowy situation on the slope · Formation status of snow cover · Snow cover crack situation · Snow quality at high altitude	· 1 time / week (winter only) · Understanding the danger of avalanche by inspection

3.2.6.1 Emergency inspection (Sequential inspection)

Emergency inspections are to be carried out immediately after the occurrence of avalanche, and urgently summarize damage scale, emergency response plan and report. Therefore, they are based on visual inspection around the road, and it is necessary to pay special attention to items (1) to (3).

In addition, during an emergency inspection, it is advisable to check the organization of snow removal and the possible danger of secondary avalanche waves through the state of avalanche deposition. Regarding the threat of an avalanche secondary wave, if an avalanche was formed during heavy snowfall in the zone of origin, and if 24 hours have passed since the last snowfall, it can be assumed that the snow cover has stabilized. When an avalanche is formed in clear or rainy weather, it is necessary, just as during planned inspection, to check the accumulation of snow on the slope, the presence or absence of snow cornices, the condition of cracks in the cover, etc.

(1) Date and time of avalanche occurrence

Avalanche occurrence date and time should be recorded.

(2) Avalanche reach range

Avalanche reach range on the road is recorded. The elements of a record are width and height of an avalanche deposition on the road.

It is advisable to indicate the borders of the avalanche deposit in a schematic form, and at least try to take photos of both ends and make descriptions.

Data on avalanche reach range as they accumulate can be extremely useful in determining the site for the placement of protective measures.

Date	Road name	Kilopost	Avalanche length on the road	Avalanche height	Influence lane	Road closing time
		**.*kp	***m (**.*～**.*kp)	**.*m	one side /both sides	*.*hours

(3) Damage from avalanches

Damage caused by avalanche such as casualties, damage of vehicles, structures and actual conditions of closing is recorded.

(4) Weather conditions at avalanche occurrence

Data about the weather, the depth of snow cover, the amount of snow precipitation and the temperature at the time of the avalanche generation are recorded. It is desirable that these indicators of measurement were from the nearest meteorological station, however, in case of inaccessibility of data from meteorological stations, general data of the region is enough.

3.2.6.2 Static inspection

Static inspections are conducted about once a year, after snow melting, and confirm the dangers of avalanches that occurred in winter. The inspection items are as follows.

(1) Sediment situation behind countermeasure structures (confirmation of pocket capacity)

Mounds and terraces on slopes lose their effectiveness as soil deposits accumulate on them. Therefore, after the snow melts, such slopes should be checked for the state of accumulation by soil sediments; at the embankment, the reverse side of the embankment is inspected, while at the terracing the terraces themselves.

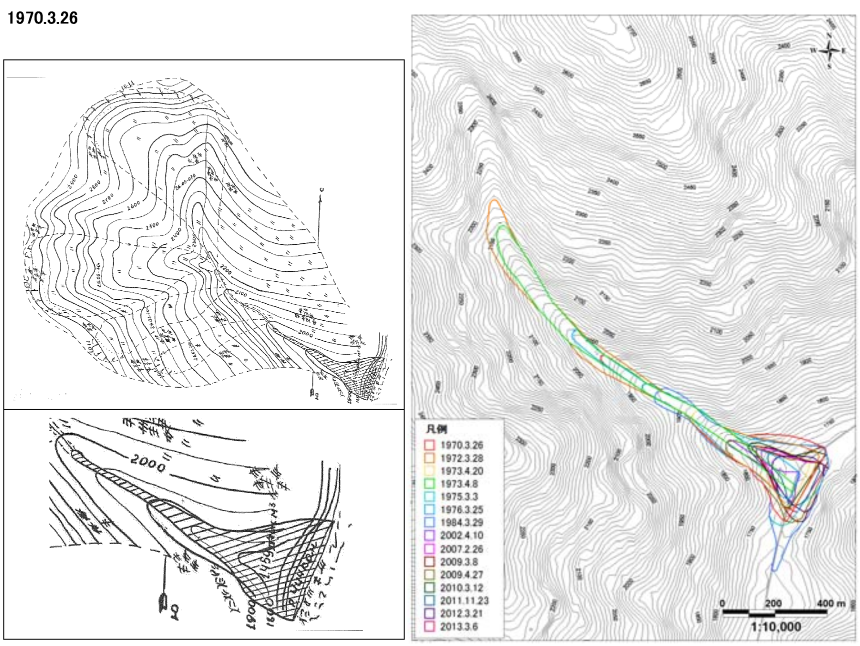
If, as a result of inspection, an increasing accumulation of soil deposits is detected, measures are needed for excavation and cleaning of deposits and stones.

(2) Topographic conditions of the avalanche slope

The topography of avalanche occurrence area, the runway and the sedimentary zone are confirmed.

(3) Confirmation of avalanche frequency and scale by saving avalanche history of occurrence place

Confirm the frequency and scale of avalanche by organizing the history of avalanche occurrence places. Historical data will be an important source for considering the scale and placement of future countermeasures.



Example of 246 km of BO road (record in plan view)

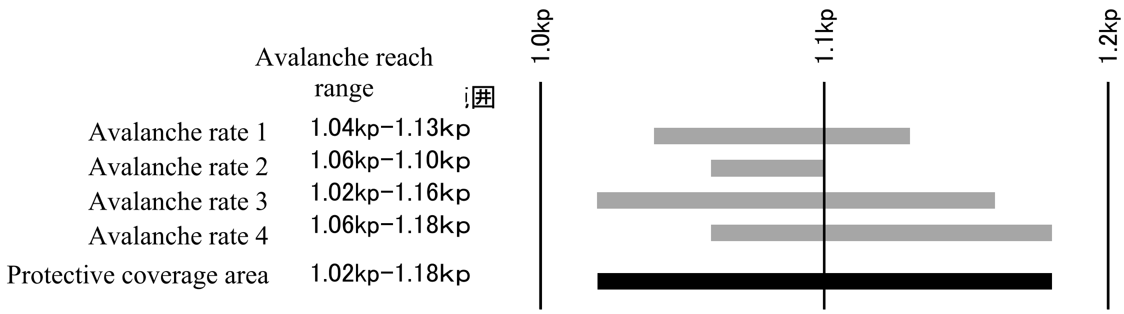


Image of type of accumulation of data on kilometers

Figure 3.2.2 Record and accumulation of avalanche generation data

(4) Condition of countermeasures structures

Checking avalanche countermeasures facilities is extremely important in judging whether facilities are working effectively or whether there are any structural problems. Thus, it is advisable to conduct inspection every year regularly, fill out the inspection results in the ledger for each facility, and organize the records.

Main check items of countermeasures facilities are as follows. If countermeasures are found to be inappropriate for damage, installation location, etc., it is advisable to promptly reinforce, replace or upgrade and to increase functionality before the winter season.

(1) Terracing

a Overall ・・・・・ Intervals

b Terrace ・・・・・ Terrace width, deposits, drainage

(2) Prevention pile, Prevention fence, Protective fence

a Overall ・・・・・Stability

b Foundation ・・・・・Lifting, breakage, settlement

c Main pillar, support pole, cross beam ・・・・・Looseness, bending, rust, looseness of bolt

(3) Protective retaining wall, avalanche breaker, guiding retaining wall

a Overall ・・・・・ breakage, crack, settlement

b Pocket (protective retaining wall) ・・・・・sediment, drainage

c Auxiliary protective fence (protective retaining wall) ・・・・・ loosening, bending, rust, bolt loosening

(4) Snow Shed (Steel)

a Overall ・・・・・stability, falling rock

b Foundation ・・・・・scouring, movement of junctions, cracks, lifting, settlement

c Roof ・・・・・ deformation, cushioning material, breakage, crack, rust

d Column, girder, etc. ・・・・・ twist, slack, looseness of anchor bolt, rust

3.2.6.3 Periodic inspection

During periodic inspection, avalanches that did not reach the road, precursors of avalanches, such as protruding of snow cornices, a state of snow accumulation on the slopes, a crack on snow cover, etc., are examined.

3.2.7 Snowdrift

3.2.7.1 General

In order to clarify disaster scale and to properly implement countermeasures taking into account priority, in case of snowdrift, unlike slope disasters such as rockfalls, it is necessary to monitor the actual snowdrifts during the winter season. Thus, observations in winter period imply observations during the formation of a snowdrift and immediately after its completion (active inspection), observation of the environment and snow cover in the absence of drifts (passive inspection). On the other hand, in order to know the potential of disaster, regardless of the presence / absence of snow, it makes sense to study in advance the data on the macroclimate, relief and environment. In any case, apart from carrying out inspections in the absence of snowdrifts, it is extremely important to unify the methods of recording data on the damage caused by snowdrifts, and then, combining several inspection results, determine the degree of danger from snowdrifts.

The table below summarizes the overall content of the inspections, which also includes the periods of inspections. It should be noted that the content of the table implies not only the Bishkek-Osh road, but also taking into account further expansion, other main roads of the Kyrgyz Republic.

Table 3.2.11Outline of Inspection for Snowdrift

Inspection phase	Inspection purpose and content	Inspection timing
Periodic inspection (Non-snowy season)	・ To understand the potential of damage caused by snowdrifts, include a study of the terrain and the state of vegetation on the windward side of the road (preferably both sides, because at the moment it may not be clear yet) ・ Due to the fact that data on meteorological conditions, which are the basic elements of snowdrifts, are not compiled (scale of drifts, wind speed and frequency of snowdrifts), it is necessary to rely on general data of meteorological observations	· It is carried out twice a year. · Record only when there is a change from last time
Sequential (emergency) inspection (When disaster occurs)	・ Conducting inspection during snowdrift and immediately after it. ・ Studying the volume of snow accumulation and the deterioration of visibility, as well as the direction of snowdrift. ・ By installing a drive recorder in a patrol car, valid data can be acquired.	· Implemented when driving at the time of snowstorm. · Recording of snow cover height at traffic closure / snow removal time

3.2.7.2 Periodic inspection

Periodic inspection of snowdrifts is aimed at gathering information to assess potential damage from snowdrifts on a certain section of the road. It is advisable to carry out in a planned manner (passive inspection). Inspection elements do not change more often than one year, so the inspection period can be determined depending on changing conditions.

As shown in Figure 3.3.2, the size of the snowdrift is determined by the weather conditions (the strength of the wind, the amount of snowfall, snow cover, etc.) that will cause the snowdrift. In addition, road structures (such as embankments and cuts) and their surroundings (flat areas on the windward side, buildings and vegetation etc.) increase snowdrift force (expansion factor) or soften it (mitigation factor). On the basis of these factors the risk of snowdrift on the road is decided. We need to make efforts to grasp this information to the minimum necessary.

Main Factor (Meteorological Condition)	+	Expansion Factor (Surrounding Environment) (Road Structure)	-	Safety Factor (Surrounding Environment) (Road Structure)	=	Degree of Snow Drifting Risk

Figure 3.2.3 Concept for Degree of Snow Drifting Risk

(1) Inspection items

Inspection items for periodic inspections are summarized in Table 3.2.12.

Due to the lack of data in the Kyrgyz Republic on meteorological conditions (weather data near the road), which are the main factor in the formation of snow cannons, it is necessary to conduct meteorological observations. However, it is not realistic to think about cost-effectiveness to develop meteorological observations for periodic inspection. In this case, it is desirable to take meteorological data from the nearest subordinate organization of the Ministry of Emergency Situations. At the same time, the technology of an approximate calculation of snowdrift volume will still be necessary, therefore, at a minimum, maximum depth of snow cover and the direction of snowdrift will be required. It should be noted that the direction of snowdrifts is highly dependent on the terrain, therefore, even after receiving data from the Ministry of Emergency Situations about the weather conditions near the site, it is necessary to carefully study it. In such cases, it is extremely important to conduct surveys and ask road workers.

Table 3.2.3 Periodic inspection items

Type	Item	Contents	Evaluation criteria
Main factors (weather conditions)	Snowdrift direction	It is necessary to conduct meteorological observation to determine the degree of snowdrift and the level of its damage to this site, and the direction of the prevailing wind as conditions for the selection of protective measures Prevailing wind direction is important in terms of angle with the road. It is well known that when the main wind direction is orthogonal to the road it leads to increase of snowdrift across the road, as a result of which snow easily accumulates and visibility deteriorates.	0～30° (Almost parallel to the road) 30～60° 60～90° (Almost orthogonal to the road)

Type	Item	Contents	Evaluation criteria
	Max depth of snow cover	The greater the amount of snow cover increases, the more difficult the snow clearing becomes, at which snow is piled up along the road. An increase in snowbanks sizes leads to an increase in snow accumulation and greatly impairs visibility.	～20cm、20～5050 50 cm、 50～100 cm、 100 m～
	Snowdrift volume	Total amount (kg / m) of snow particles passing laterally through a certain point when a snowdrift occurs is referred to as the snowdrift volume. Snowdrift volume here is the cumulative value for one winter season. It is often estimated from normal meteorological data (wind speed, air temperature, snow cover). This values directly express snowdrift size.	～20m^3/m、 20～30 m^3/m、 30～40 m^3/m、 40m^3/m～ ※ Assuming 350kg/m^3
Expansion / Safety factors (surrounding, environment etc.)	Terrain	Snowdrifts are difficult to form, if the terrain from which a blizzard blows is hilly and extremely uneven, and it is easily formed, if there is even a small incline and flat terrain.	Mountainous area Flat area：～100m、100～300m、300m～ ※Refer to Figure 3.2.3 for judgment of flat area
	Vegetation Buildings	In the section where the houses are on the windward side and in the section where the forest zone (evergreen conifer with snow protection effect) with a certain level of height and leaf density is present, it has the effect of blocking the snowstorm, so from the viewpoint of preventing snowdrift presence/absence of this factor can be used as a criterion for evaluation. Evaluate by the width in the road crossing direction of a houses or forest that is continuous to a certain extent in the road direction (refer to Figure 3.2.4)	None、～10m、10～30m、30m～
	Road constructions	The higher the embankment and the higher the height of the road, the more snow removal space is secured outside the road, making snowy banks harder to generate on the road side. Therefore, it does not allow deterioration of visibility. Also, the shallower the cut is, the easier it is for snowfall to enter from the top of the cut and the more likely snowdrift occurs.	Embankment (Height～1m、1m～) Flat area Cut slope (Depth～3m、3m～) Bridge
Other factors	Road closure frequency	The greater the frequency of traffic closure due to the snowstorm, the weaker the road is against the snowdrift. It can be said that the priority of countermeasures against snowdrifts is very high.	None, about once in several years, about once a year, several times a year.

Type	Item	Contents	Evaluation criteria
	Traffic accident / disability frequency	We record traffic blocking time due to traffic accidents (frontal collision, rear end collision, out of road deviation) and influences of snowdrift and visibility obstruction.	None, about once in several years, about once a year, several times a year.
	Snow removal difficulty	The priority of carrying out protective measures is determined by the level of difficulty in carrying out snow cleaning and the cost of human and temporary resources. In particular, due to the peculiarities of the road line, road construction, the amount of snow accumulation, etc., for the unimpeded maintenance of the road.	None, about once in several years, about once a year, several times a year.

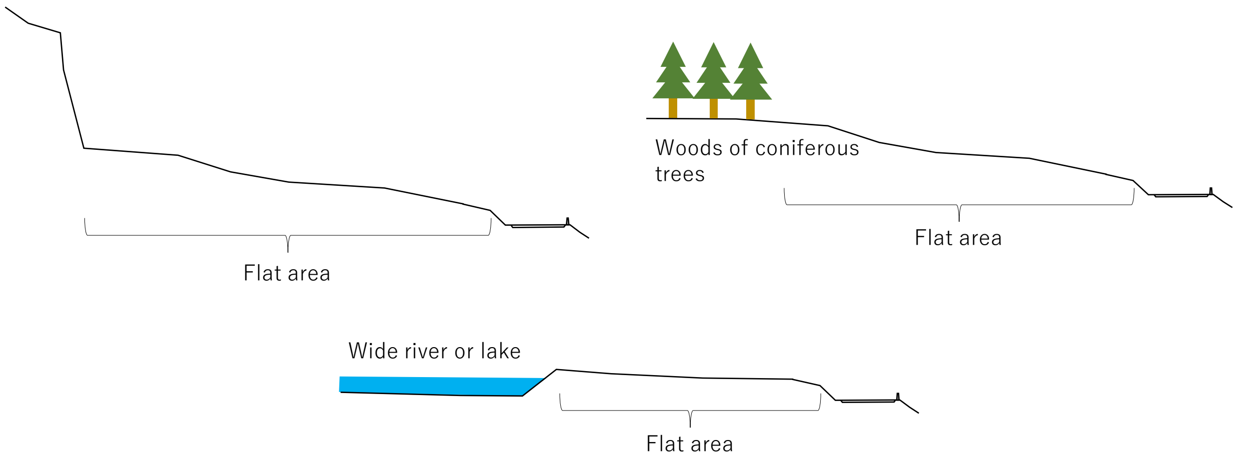


Figure 3.2.4 How to capture a flat area

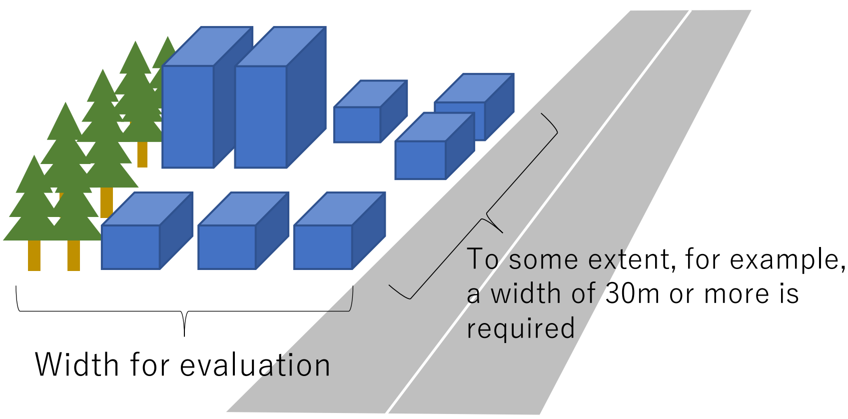


Figure 3.2.5 Images of widths of buildings and vegetation beside the road

(2) Check points

Areas to be inspected do not cover all the road. First, the sites are screened out according to the degree of damage from snowdrifts on the target road, then, guided by the knowledge (acquired knowledge) of the DEU workers, zones are identified that are prone to snowdrifts (already conducted at DEU-9 and DEU-23 at Bishkek Osh road). These sites should be subject to periodic inspections.

Also, it is necessary to evaluate separately areas with inconstantly scale of damage caused by snowdrift, with difference in road structure, topography and vegetation. Figure 3.2.6 shows the image that divides the sections to be evaluated. It is not necessary to divide the sections into very small sections, but it is desirable to divide the section where the factor affecting the snowdrift clearly differs.

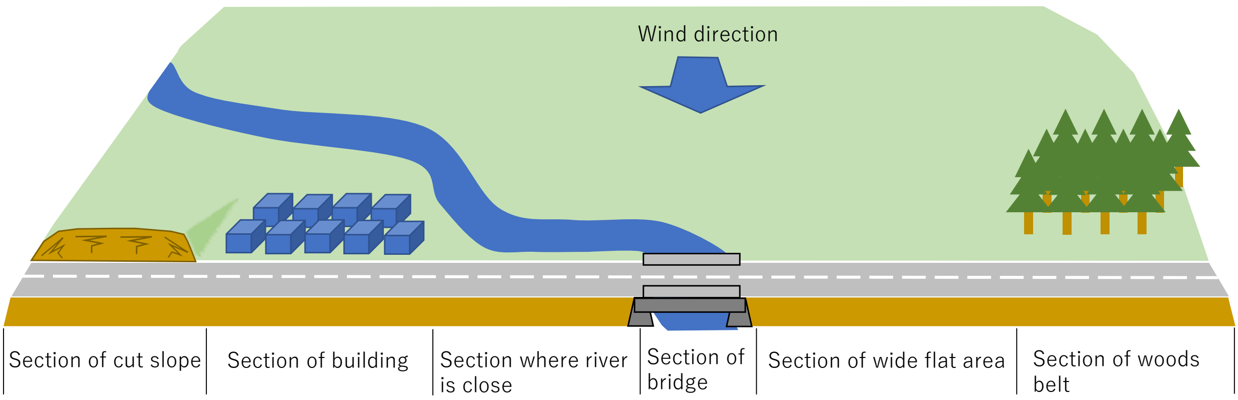


Figure 3.2.6 Section division image in periodic inspection

3.2.7.3 Sequential (emergency) inspection

It is extremely important to record the level of damage during the formation of snowdrifts (active inspection). The level of damage implies in which section and in what volume snowdrifts were formed (the scale of snowdrift on the road and the scale of visibility obstruction).

(1) Visibility obstruction

In case of damage caused by snowdrift in area where planned inspection is being conducted (risk zone of snowdrift), it is necessary to inspect this site 2-3 times and make records of the scale of snowdrift along the kilometer posts in the special form indicated below. The level of visibility is determined and evaluated visually. The division into visibility levels is shown in Photo 3.2.1. The form introduces the lowest level of visibility (level A, level B, level C) in the surveyed area according to the table. The scale of visibility obstruction is described in Table 3.2.12 and is based on the results of research. These results show that when visibility is 100 m-200 m, motor transport begins to slow down due to deterioration of visibility, while driving is stable. When visibility deteriorates to 100 m, the speed drops even more, and driving becomes difficult. When visibility deteriorates to 50 m, following of the road line becomes more complicated and driver seems to want to stop vehicle. Consequently, the level of visibility of less than 100 m can be considered an unacceptable degree of damage caused by snowdrift. In order to justify the recordings, you should take video and pictures.

Visibility over 200 m

Level C: Visibility 100-200 m

Level B: Visibility 50-100 m

Level A : Visibility less than 50 m

Photo3.2.1 Samples of visibility obstruction situation

Table 3.2.4 Relationship between visibility and traffic behavior / driving behavior [1]

Visibility	traffic behavior / driving behavior
less than 50m	【Moving speed is considerably slowing down, keeping the lane is very difficult】 ○ Deceleration by brake operation increases ○ Many motions to the left and right also become unstable ○ The situation in which you want to stop driving, but have to continue driving.
50 m ～ 100 m	【Running at low speed is unstable in the longitudinal direction】 ○ The traveling speed further decreases ○ Acceleration operation becomes frequent, and the speed difference between vehicles increases ○ Therefore, tracking and vehicle group traveling increases
100 m ～ 200 m	【Moving speed starts to decelerate but driving is stable】 ○ Speed reduction due to reduced visibility ○ The difference in the speeds of vehicles is not noticeable ○ Stable acceleration and braking

[1] Yasuhiko Kajiya, Masaru Matsuzawa, Takehiko Suzuki, Kazuhiro Tanji, Yasuhiro Nagata, 2004: Investigation of the process of driving in terms of interference visibility due to snowfall and snow storm. 20th Cold Region Technology Conference. Collection of technical reports and accounts, Vol.21, 325-331.

(2) Snowdrift

Understanding the size of the snowdrift formed on the road. It is difficult to directly measure the depth and spreading range of the snowdrift at the time of visibility obstruction occurrence or at the time of traffic closure due to the snowstorm. Therefore, when the vehicle can run, the assistant at the front passenger seat records the approximate position of the snowdrift and the size of the snowdrift while traveling. In addition, it is also possible to conduct a post-survey at the stage between the snowstorm will end and the snow removal work will be started for opening the road. Basically, the survey item is the deepest part of the snowdrift adjacent to the road. As well as visibility obstruction, it is necessary to take videos and photographs as much as possible to support records.

Table 3.2.5 Snowdrift categories chart

Width \ depth	0.2～0.5m	0.5～1.0m	1.0m～
c	D	C	C
b	C	B	B
a	B	A	A

a：Snowdrift covers the entire width of the travel lane or about half of the lane on the leeward side

b：Snowdrift approximately to the center line

c：Snowdrift covers the vicinity of the outside line of the lane on the windward side or half of the lane

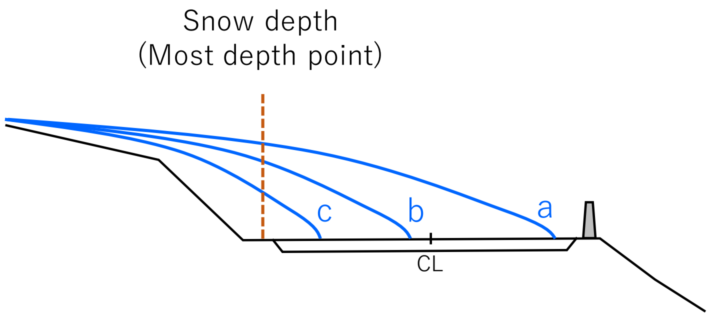


Figure 3.2.7 Measurement points for the width and depth of the snowdrift

3.2.7.4 Recording method

(1) Periodic inspection

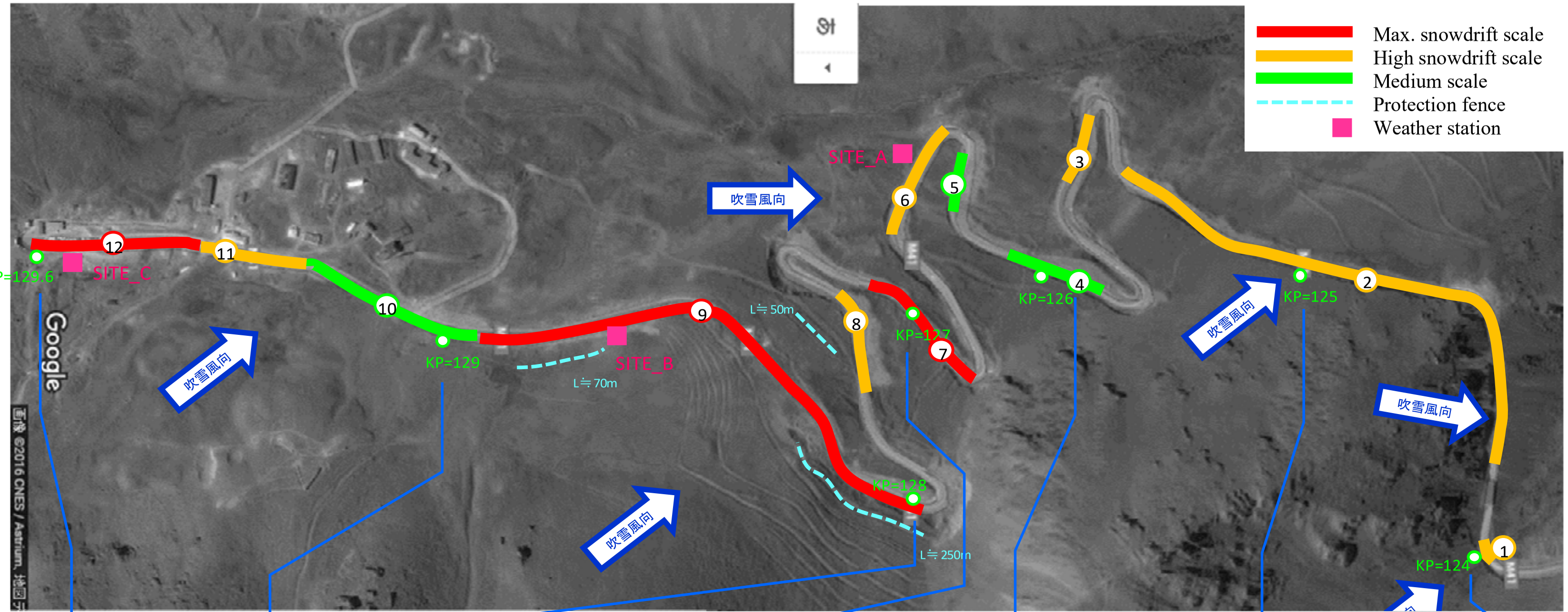
Records of the results of periodic inspections should be arranged in the sheet shown in Figure 3.2.7.

(2) Sequential (emergency) inspection

Records of the results of sequential (emergency) inspections should be arranged in the sheets shown in Figure 3.2.8 and Figure 3.2.9. Those sheets were prepared for Too-Ashuu Pass and Ala-Bel Pass separately so the appropriate form should be used. Figure 3.2.10 shows the filled sample. Enter comments and observations on snowdrifts in remarks column.

Section(km)				Weather conditions						Surrounding environment etc.						Other factors						Score	Evaluation Rank
starting point		end point	Extension	Snowdrift direction		Maximum snow depth		Snowdrift volume		Terrain		Vegetation /Building		Road structure		Frequency of traffic closure		Traffic Accident Frequency		Snow removal difficulty			
100,0	～	100,5	0,5	O～30°	1	50～100cm	3	40m^3/m～	4	Flat area～100m	2	None	4	Embankment～1m	3	Once a year	2	None	0	None	0	19	B
100,5	～	101,1	0,6	30～60°	2	50～100cm	3	40m^3/m～	4	Flat area～100m	2	None	4	Embankment～1m	3	Once a year	2	None	0	None	0	20	B
101,1	～	101,5	0,4	30～60°	2	50～100cm	3	40m^3/m～	4	Flat area 100～300m	3	building 10～30m	2	Embankment 1m～	1	Once a year	2	None	0	None	0	17	C
101,5	～	102,5	1,0	30～60°	2	50～100cm	3	40m^3/m～	4	Flat area 300m～	4	None	4	Embankment 1m～	1	Once a year	2	None	0	None	0	20	B
102,5	～	102,9	0,4	30～60°	2	50～100cm	3	40m^3/m～	4	Flat area 300m～	4	Vegetation～10m	3	Embankment～1m	3	Once a year	2	None	0	None	0	21	B
102,9	～	104,4	1,5	30～60°	2	50～100cm	3	40m^3/m～	4	Flat area 300m～	4	None	4	Embankment～1m	3	Once a year	2	None	0	None	0	22	B
104,4	～	105,8	1,4	60～90°	3	50～100cm	3	40m^3/m～	4	Flat area 300m～	4	None	4	Embankment～1m	3	Once a year	2	1 time / a few years	1	Several times / year	3	27	A
105,8	～	106,0	0,2	60～90°	3	50～100cm	3	40m^3/m～	4	Flat area 300m～	4	None	4	Cut slope ～3m	3	Once a year	2	once a year	2	Several times / year	3	28	A
106,0	～	107,0	1,0	O～30°	1	50～100cm	3	40m^3/m～	4	Flat area～100m	2	None	4	Embankment～1m	3	Once a year	2	1 time / a few years	1	None	0	20	B

Figure 3.2.8 Example of periodic inspection sheet



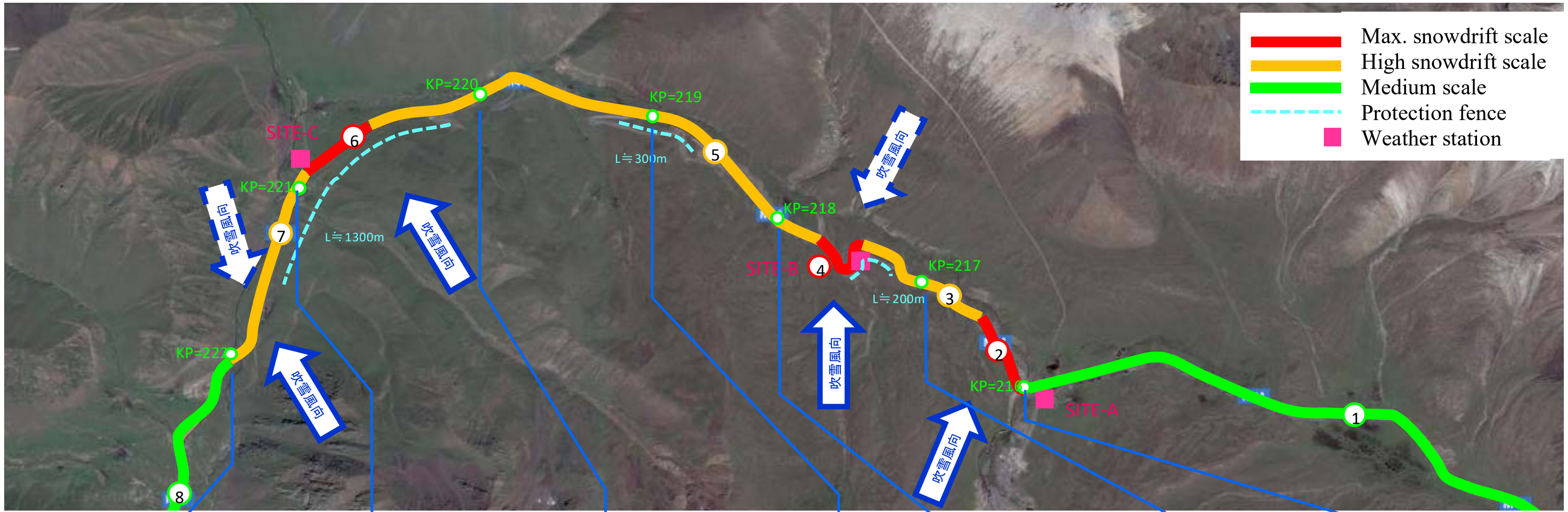
KP(span200m)	129,6	129	128	127	126	125	124
Visibility Rank							
Remarks							
Snowdrift Rank							
Remarks							
Etcetera							

Inspection Date : Inspector

【Remarks】

Legend
Visibility Rank : A(～50m)・B(50～100m)・C(100～200m)
Snowdrift Rank : A(1.0m～)・B(0.5～1.0m)・C(0.2～0.5m)

Figure 3.2.9 Sequential (emergency) inspection sheet (Too-Ashuu pass)



KP(span200m)	222	221	220	219	218	217	216
Visibility Rank							
Remarks							
Snowdrift Rank							
Remarks							
Etcetera							

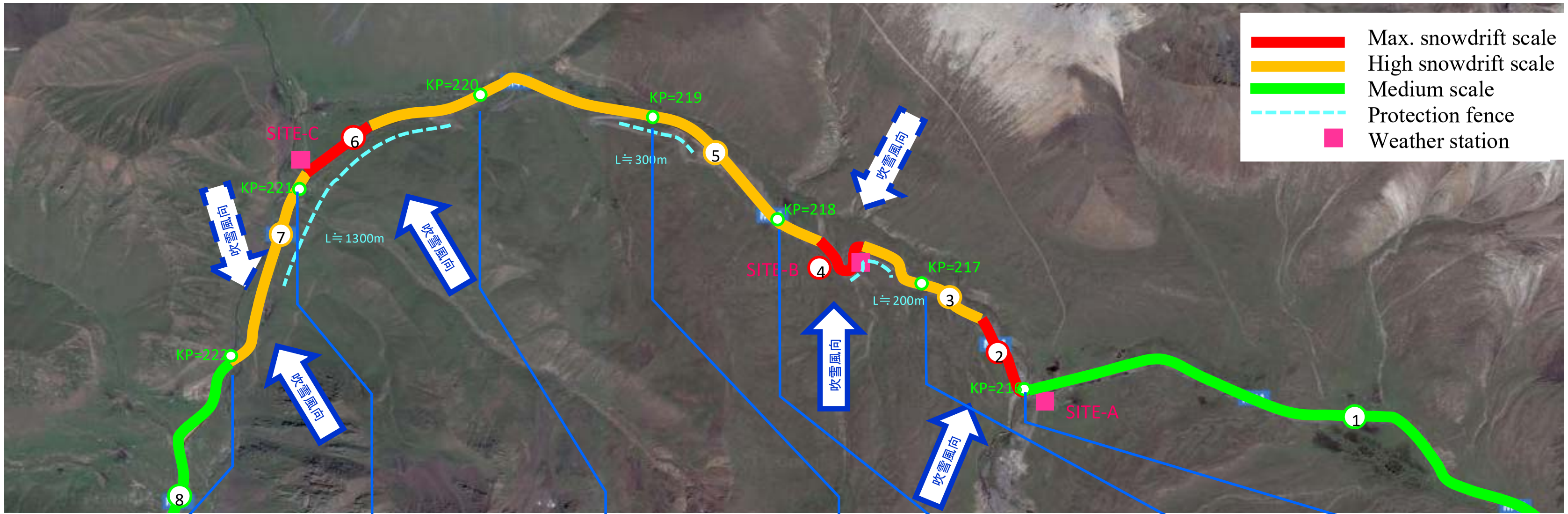
Inspection date : Inspector

【Remarks】

Legend Visibility Rank : A(～50m) ・ B(50～100m) ・ C(100～200m)

Snowdrift Rank : A(1.0m～) ・ B(0.5～1.0m) ・ C(0.2～0.5m)

Figure 3.2.10 Sequential (emergency) inspection sheet (Ala-Bel pass)



KP(span200m)	222–221	221–220	220–219	219–218	218–217	217–216
Visibility Rank	C	A	C	B	A	B / A
Remarks		Driving is impossible due to visibility failure				
Snowdrift Rank		B	B / C	C	B / A	C
Remarks					↑ All widths are filled with a snowdrift	
Etcetera		Three cars stuck in this section				

Inspection date：2016/11/15 13:00~15:00 Inspector Masaya Otsuki

Legend Visibility Rank : A(～50m)・B(50～100m)・C(100～200m)
Snowdrift Rank : A(1.0m～)・B(0.5～1.0m)・C(0.2～0.5m)

【Remarks】
It was the biggest snowdrift of the season.

Figure 3.2.11 Sequential (emergency) inspection (filling example)

3.3 Monitoring of Road Disaster

3.3.1 General

Monitoring can predict the occurrence of disasters in advance and prepare necessary preparations by grasping the relationship between disasters and changes in weather conditions and natural environment, Predicting the occurrence of disasters from data of weather change and preserving human lives by restricting access to dangerous road sections. It is also possible to grasp the signs of the occurrence of the disaster in advance and to suppress the spread of the damage by carrying out emergency countermeasure construction. Because of this, the monitoring activity is high value and it does not require a large budget compared with direct construction cost. Because of this, the monitoring activity is high value and it does not require a large budget compared with direct construction cost. Therefore, it is desirable to positively using the monitoring work.

3.3.2 Meteorological Data

Rainfall, snowfall, melting snow, temperature, wind speed, etc. These monitoring items are selected by types of disaster. (now tentative)

3.3.3 Measurement FOR Quantity OF Displacement

The most important thing on the slope disaster monitoring is to grasp the tendency of the behavior of the slope over time. The most fundamental monitoring method is measurement between two points with cracks, steps, and it directly grasps behaviors of l moving masses due to sediment-related disasters. Depending on the type of disaster, it is important to check the trends of disasters and moving speed before expanding and accelerating. Measurement using simple installation equipment with wood piles and rivets is also general, and a schematic diagram of a general measurement method of displacement on the slope is shown on Picture 3.3.1.

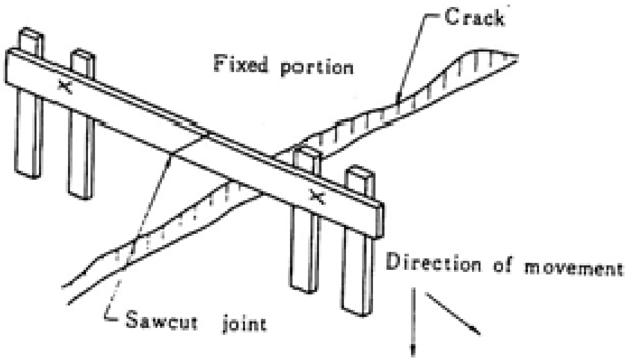


Figure 3.3.1 Simple Displacement Plate

Record and collect data at the monitoring points according to the field survey results. The main measurement method and its purpose are summarized in the Table 3.3.1.

Table 3.3.1 Measurement Method and Purpose

Contents	Equipment	Setting point	Purpose for monitoring
Measurement of displacement of step and crack	Wood pile, nail · rivet Simple marking Extensometer	Natural slope, cracks in slope, step Fracture of rock Crack on the road surface Opening of unstable bedrock and ground	Landslide, slope collapse, rock collapse, cracks on road surface, Install in the place where the change in displacement amount is predicted as the deformation progresses and check the amount of change
Movement and extrusion of the ground	Pile, pole, nails Concrete bench mark	Place in a straight line across stable ground and sliding parts Natural slope (wood pile), road surface (tack), etc.	Confirm the moving direction and speed of each installation point due to extrusion fluctuation caused by landslide etc.
Measurement of the enlargement of the cliff line by collapse	Wood pile, etc.	Just above the collapsed cliff and continue to place on the slope behind	Progress of collapse, grasp of the speed of collapse

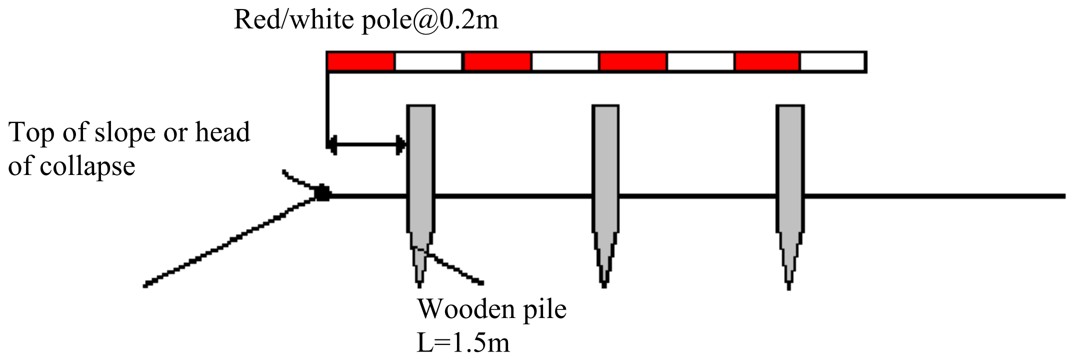


Figure 3.3.2 Measurement of the enlargement of the cliff line by collapse

3.3.4 Monitoring for Ground Water

One of the biggest incentives for slope disasters is the behavior of groundwater, especially the groundwater level rising as a factor that increases the activity of landslides. Uplifting in the groundwater level will increase the sliding power that moves the landslide below the slope, making the balance of the soil masses unstable. Therefore, it is one of the most important monitoring to monitor the slope disaster, to periodically measure the depth of the groundwater level and compare it with the behavior of the slope described in 3.3.3.

It is impossible to measure the depth of the groundwater level without observable wells or underground water observation holes by boring survey. It is also important to observe the spring water and surface water on the surface as shown in the table below and to check the relationship with the slope fluctuation caused by the disaster. In particular, immediately before the occurrence of landslide and debris flow, signs such as the amount of spring water and surface water increase and decrease, the color tone changes and turbidity are confirmed.

Table 3.3.2 Measurement Method and Purpose

Contents	Equipment	Setting point	Purpose for monitoring
Discharge water	Measuring cups	Spring point in the landslide area and around the site of the collapse	Confirmation of correlation between landslide moving and change in spring water volume, Confirmation of spring water color tone
Spring water	Measuring cups, bucket cell	Surface water in the waterway or stream around the landslide area	Confirmation of correlation between landslide moving and change in spring water volume, Confirmation of spring water color tone

3.4 Evaluation of Road Disaster

3.4.1 General

Regarding the evaluation of road disaster, it is necessary to pay attention to the degree of risk and the business priority of countermeasure work。 In this chapter, explain the risk assessment (focusing on the scale and activity of the disaster) judged from the field survey results. The evaluation of project priority is explained in "Manual for short-term and medium-term road disaster prevention management plans".

Risk assess of road disaster should be implemented by several items. Risk assess is divided into 4 stages relatively, and approximate evaluation criteria of each stage are arranged as follows (Table 3.4.1).

Table 3.4.1 Focus criteria for risk assessment

Class	Focus criteria for risk assessment
S	・ The risk of disaster is extremely high over the years ・ Urgently need of disaster prevention work
A	・ Although the risk of disaster is high, but it will be change by external factors such as weather condition ・ When a disaster occurs, maintenance and management activities are required tentatively, but necessity of preventive and disaster prevention work is high（The time and expenditure for maintenance and management activities are large, and considerable efficiency improvement can be expected by preventive disaster prevention work.）
B	・ The risk of disaster is moderate, and measures are taken by regular monitoring and maintenance activities（The time and cost of maintenance and management activities is not large, and recovery of road traffic can be expected within the normal budget） ・ There is necessity of disaster prevention work, but there is not so much urgency
C	・ The risk of disaster is low ・ Responded by periodic monitoring ・ Maintenance and management activities may be carried out as necessary, but the necessity of preventive disaster prevention works is low

※Maintenance and management activity is the road traffic restoration work by removal of stone etc. after a disaster

The above evaluation is subject to change due to condition in natural conditions over time (progression of climate change, weathering / erosion, topography change, flow rate of groundwater / surface water, amount of viability, change of flow route etc.) So, the evaluation is not fixed for a long time. Therefore, it is important to set up opportunities for review by conducting periodic inspections and detailed inspections, even if the disasters do not occur.

3.4.2 Rockfall

The risk of rockfall is evaluated by the scale and frequency of rockfall. The point of interest in falling stone risk assessment should be set by the size of the falling rock and probability of occurrence. The scale of the falling stone disaster can be inferred by confirming the size and quantity of the unstable rock mass of the source, the ratio from the road, the gradient of the slope, etc. by field survey. On the other hand, estimating the probability of falling rock disasters is extremely difficult. To make a judgment as to whether the target unstable rock mass falls within 1 year, 5 years, 10 years or less is difficult except for some cases such as the stability of falling rocks being numerically monitored. Therefore, it is desirable to set the probability of falling rocks with priority to urgency, based on the occurrence history of the falling rock disaster at the relevant part and the data of the similar geographical feature.

The criteria (draft) for evaluation is shown below.

【Scale of the rockfall】

Height of the rock slope/ cliff

- H: over 100m
- M: 100～30m
- L: less than 30m

【Urgency of falling rock measures】

Within 5 years, include a neighboring district with topographical and geological conditions matching site

- H: Falling rock disasters affecting human beings and vehicles has been occurred or falling rocks has caused a road blocking of 24 hours more has occurred
- M: A falling rock with a road blocking of more than half a day has occurred
- L: The damage corresponding to the above has not occur

Table 3.4.2 Evaluation for Rockfall risk

Scale＼Emergency	H	M	L
H	S	A	A
M	A	B	B
L	A	B	C

3.4.3 Landslide

The risk of landslide is evaluated by the scale and activity of landslide. The point of focus in assessing the risk of landslides is the activity and scale of the landslide Activity of landslide can generally be estimated from the moving quantity and speed of the landslide head part. It is possible to inspect the moving speed and activity by monitoring with the pile measurements or extensometers at the step of the landslide area head. (shown in table 3.4.3)

Table 3.4.3 Landslide criterion based on observation results of ground extensometers

Type of displacement variation	Daily displacement (mm)	Cumulative displacement (mm/month)	Cumulative trend in the same direction	Overall evaluation	
				Landslide evaluation	Activity level, etc.
Type A	More than 1	More than 10	Significant	Definite	Actively moving, surface and deep slides
Type B	0.1 – 1	2 – 10	Less significant	Almost definite	Slowly moving, clayey and collusive slides
Type C	0.02 – 0.1	0.5 – 2	Slight	Latent	Continuous monitoring necessary
Type D	More than 0.1	None (Intermittent displacement)	None	Abnormal	Local ground deformation, others

(Reference; Guidelines for Landslide Prevention Technologies Sep2007)

The scale of the landslide disaster (= the amount of the moving soil mass) can be inferred from the width, the length, and the depth of the landslide block. The large landslide in the planar area has large soil mass and the landslide scale is also large.

【Activity of the landslide】

From the table 3.4.3

- H: A class moving Landslide moving is certainly occurring
- M: B class moving Landslide moving is uncertain
- L: C class moving Landslide moving is potentially occurring

If the monitoring is not carried out, refer to the following

Within 5 years,

- H: Landslide affecting human beings and vehicles has been occurred or sliding deposits has caused a road blocking of 24 hours more has occurred
- M: Landslide with a road blocking of more than half a day has occurred
- L: The damage corresponding to the above has not occur

【Scale of landslide】

- H: Estimation of moving mass amount over 300,000 ㎥
- M: Estimation of moving mass amount 10,000～300,000 ㎥
- L: Estimation of moving mass amount Less than 10,000 ㎥

Table 3.4.4 Evaluation of Landslide risk

Scale＼Activity	H	M	L
H	S	A	A
M	A	B	B
L	A	B	C

3.4.4 Slope Collapse

The risk of slope collapse is evaluated by the scale and frequency of slope collapse. It is difficult to estimate the timing of the slope collapse activity until the trigger of heavy rain, earthquake and other incidents occurs and activities become full-scale. Therefore, the activity is estimated from the adjacent slope where the past disaster history and topography and geological condition in the area are similar.

The scale of slope collapse (= amount of moving mass) can be classified based on the height of the slope. In the slope where the specific height is large, the amount of collapsed mass increases, so the evaluation of the collapse scale becomes large.

【Activity of slope collapse】

Within 5 years, include a neighboring district with topographical and geological conditions matching site

- H: Slope collapse affecting human beings and vehicles has been occurred or sliding deposits has caused a road blocking of 24 hours more has occurred
- M: Slope collapse with a road blocking of more than half a day has occurred
- L: The damage corresponding to the above has not occur

【Scale of slope collapse】

- H: Height of the slope over 30m
- M: Height of the slope 50～15 m
- L: Height of the slope 15m

Table 3.4.5 Evaluation of Slope Collapse risk

Scale＼Activity	H	M	L
H	S	A	A
M	A	B	B
L	A	B	C

3.4.5 Debris Flow

The risk of debris flow is evaluated by the scale and frequency of debris flow.

Debris flow occurred at the upstream of mountain or streambed due to heavy rain or snow melting. Presumption of the volume of sediment production/movement and calculation of peak discharge of debris flow based on the detailed inspection at the upstream of mountain or streambed are required and not easy. Since debris flow rapidly passes through the road with huge stream of water, it is not easy to calculate the actual amount of debris flow.

Thus, the scale of debris flow is evaluated by duration to affect the road traffic (i.e. duration to remove the debris on the road). Besides, the risk of debris flow is evaluated by both scale and frequency.

【Scale of Debris Flow】

Over the past five years:

- H: Debris flow disaster which affected the road user and the vehicle has occurred, or debris flow has suspended the road traffic for over 24 hours
- M: Debris flow has suspended the road traffic for over 12 hours
- L: Debris flow has not occurred

【Frequency of Debris Flow】

- H: Several times a year
- M: Once or twice a year
- L: Once in several years

Table 3.4.6 Evaluation of Hazard Level for Debris Flow

Scale \Frequency	H	M	L
H	S	A	A
M	A	B	B
L	A	B	C

3.4.6 Riverbank Erosion

The risk of riverbank erosion is evaluated by both the following degree of progress and proximity.

【Degree of progress of riverbank erosion】

- H: Revetment/spur dike has not installed, or installed but damaged. Besides, the progress of riverbank erosion is visually recognized every year
- M: The progress of riverbank erosion is not visually recognized. However, revetment/spur dike has not installed, or installed but damaged.
- L: The progress of riverbank erosion is not visually recognized. Besides, revetment/spur dike have properly installed without damage/collapse.

【Degree of proximity between road and riverbank】

- H: The distance between road and top of riverbank is less than 5m. Besides, revetment/spur dike has not installed, or installed but damaged.
- M: The distance between road and top of riverbank is less than 10m. Besides, revetment/spur dike has not installed, or installed but damaged.
- L: Revetment/spur dike have properly installed without damage/collapse.

Table 3.4.7 Evaluation of Hazard Level for Riverbank Erosion

Progress\Proximity	H	M	L
H	S	A	A
M	A	B	B
L	A	B	C

3.4.7 Avalanche

It is desirable to evaluate the avalanche risk assessment by the damage and scale of the avalanches in the past. Since the avalanche is a reproducible phenomenon by year, so if the same conditions are formed on the slope where the avalanches had occurred like same amount of snow cover and snowfall, the danger of an avalanche increases.

【Damage from avalanches】

- H: Avalanche occurrence leads to human casualties or vehicle damage or road closing for more than 24 hours
- M: Avalanche occurrence leads to road closing for more than 12 hours
- L: The above noted damage is not observed

【Frequency of avalanche occurrence】

- H: An avalanche occurs every year
- M: An avalanche occurs about once every two or three years
- L: There is a history of occurrence of avalanche in the past, now it is a terrain with high risk of avalanche

Table 3.4.8 Avalanche risk assessment

Frequency\Damage	H	M	L
H	S	A	A
M	A	B	B
L	A	B	C

3.4.8 Snowdrift

In order to prioritize and divide sections of construction of protective measures against snowdrifts into long-term, medium-term and short-term phases, it is necessary to lay all the results of inspections and select the areas with the greatest scale of damage from snowdrifts (heavy snow accumulation and deterioration of visibility) and with the highest frequency. In particular, these are the results of the “Periodic Inspection”, which reflects the potential of snowdrifts and the “Emergency Inspection”, which shows actual degree of snowdrift damage.

"Periodic inspection result" scores the rank of each evaluation item (Table 3.4.9) and classifies it into A rank, B rank, and C rank in total (Table 3.4.10). It should be noted here that this rank does not have an absolute meaning, but it is a relative rank.

The results of a sequential (emergency) inspection after a snowdrift show the frequency of formation and the extent of damage from snow congestion and deterioration of visibility in each section. Figure 3.4.1 shows a chart of frequency of visibility obstruction by scale. The horizontal axis shows the distance (it is desirable to record at approximately 100 m intervals depending on the section to be read), and the vertical axis shows the ratio of disaster occurrence number per scale to the number of survey (record) times by a bar graph. From this graph, it can be read that in the interval from 127.8 km to 129.0 km, where visibility deteriorates to Level A, the area with the most severe deterioration of visibility is 128.6 ～ 128.8 km. Frequency by damage scale can also be summarized in the same way. Here, this is called the snowdrift damage rank, together with the snowdrift potential, it is used for risk assessment and evaluation of priority of measures.

Table 3.4.9 Evaluation scores of snowdrift potential (provisional)

Evaluation item		Score			
Weather conditions	Snowdrift direction	0～30°	30～60°	60～90°	
		1	2	3	
	Maximum snow depth	～20cm	20～50cm	50～100cm	100cm～
		1	2	3	4
	Volume of snowdrift	～20m^3/m	20～30m^3/m	30～40m^3/m	40m^3/m～
		1	2	3	4
Surrounding environment	Terrain	Mountainous area	Flat area ～100m	Flat area 100～300m	Flat area 300m～
		1	2	3	4
	Vegetation\ Building	None	～10m	10～30m	30m～
		4	3	2	1
	Road structures	Embankment ～1m	Embankment 1m～	Cut slope ～3m	Cut slope 3m～
		3	1	3	1
Other	Road closure frequency	None	1 time / a few years	About once a year	About several times / year
		0	1	2	3
	Traffic accident / disability frequency	None	1 time / a few years	About once a year	About several times / year
		0	1	2	3
	Snow removal difficulty	None	1 time / a few years	About once a year	About several times / year
		0	1	2	3

Table 3.4.10 Evaluation of snowdrift potential (provisional)

Snowdrift potential rank	Score	Overview
A	27～31	The risk of snowdrift is extremely high
B	18～26	High risk of snowdrift
C	11～17	There is a danger of snowdrift
D	6～10	There is little danger of snowdrift

The classification of snowdrift damage consists of two assessments of visibility obstruction and snow accumulation, therefore, using the risk assessment table for snowdrifts (Table 3.4.11), the conversion is carried out on the classification as follows. Upon conversion, the results are applied in order of H → M → L.

- H: "Visibility obstruction at less than 50 m is 50% and "Category B snow accumulation damage is more than 70%"
- M: "Visibility obstruction at less than 50 m is 30% and "Category B snow accumulation damage is more than 30%"
- L: Other than those above

Table 3.4.8 Snow drift risk assessment

Snowdrift Damage rank \ Snowdrift Potential rank	H	M	L
A	S	A	B
B	S	A	C
C	A	B	C
D	B	B	C

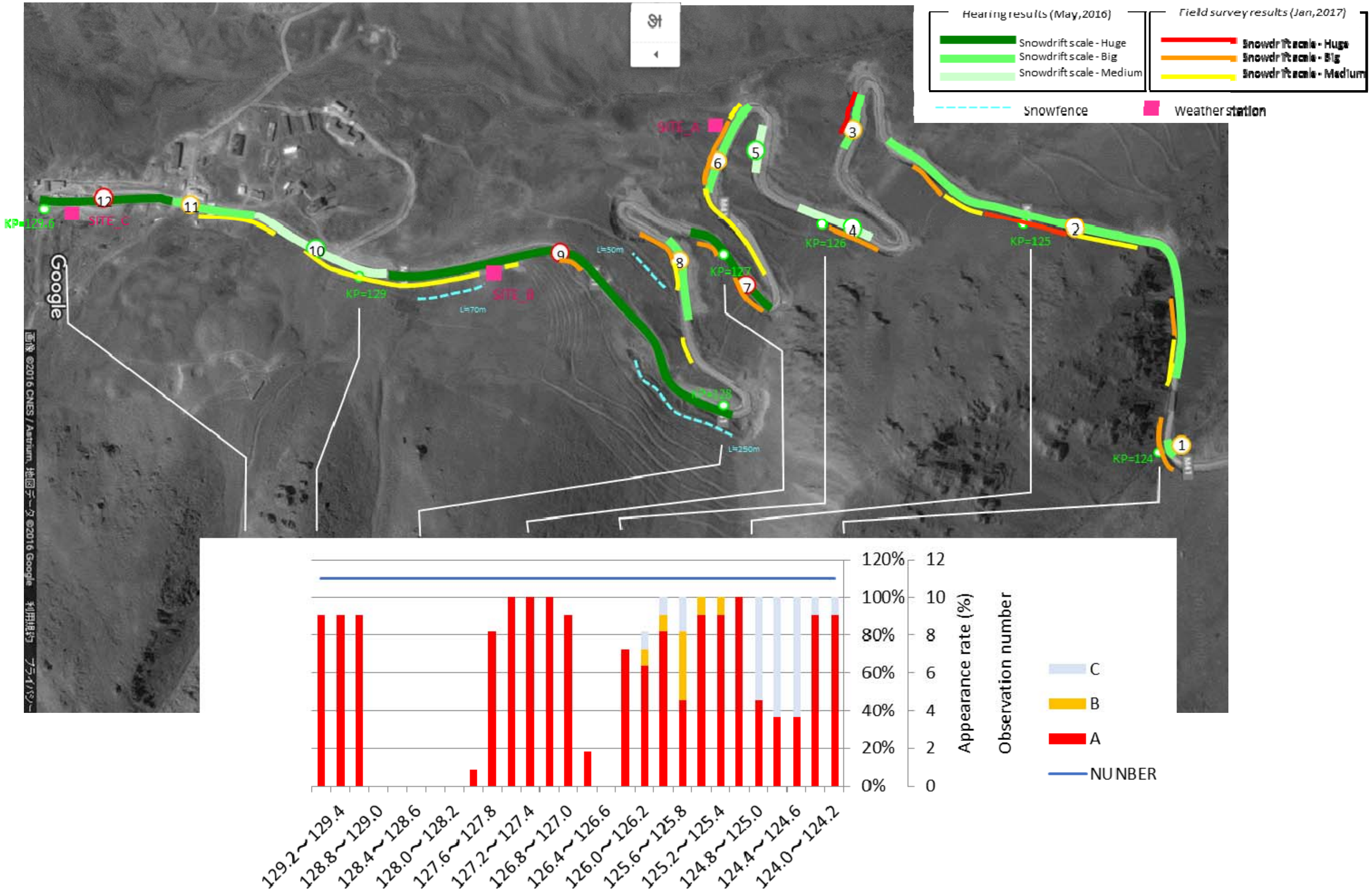


Figure 3.4.1 Example of snowdrift inspection results overwrite (2016-2017: Too-Ashuu pass: visibility)

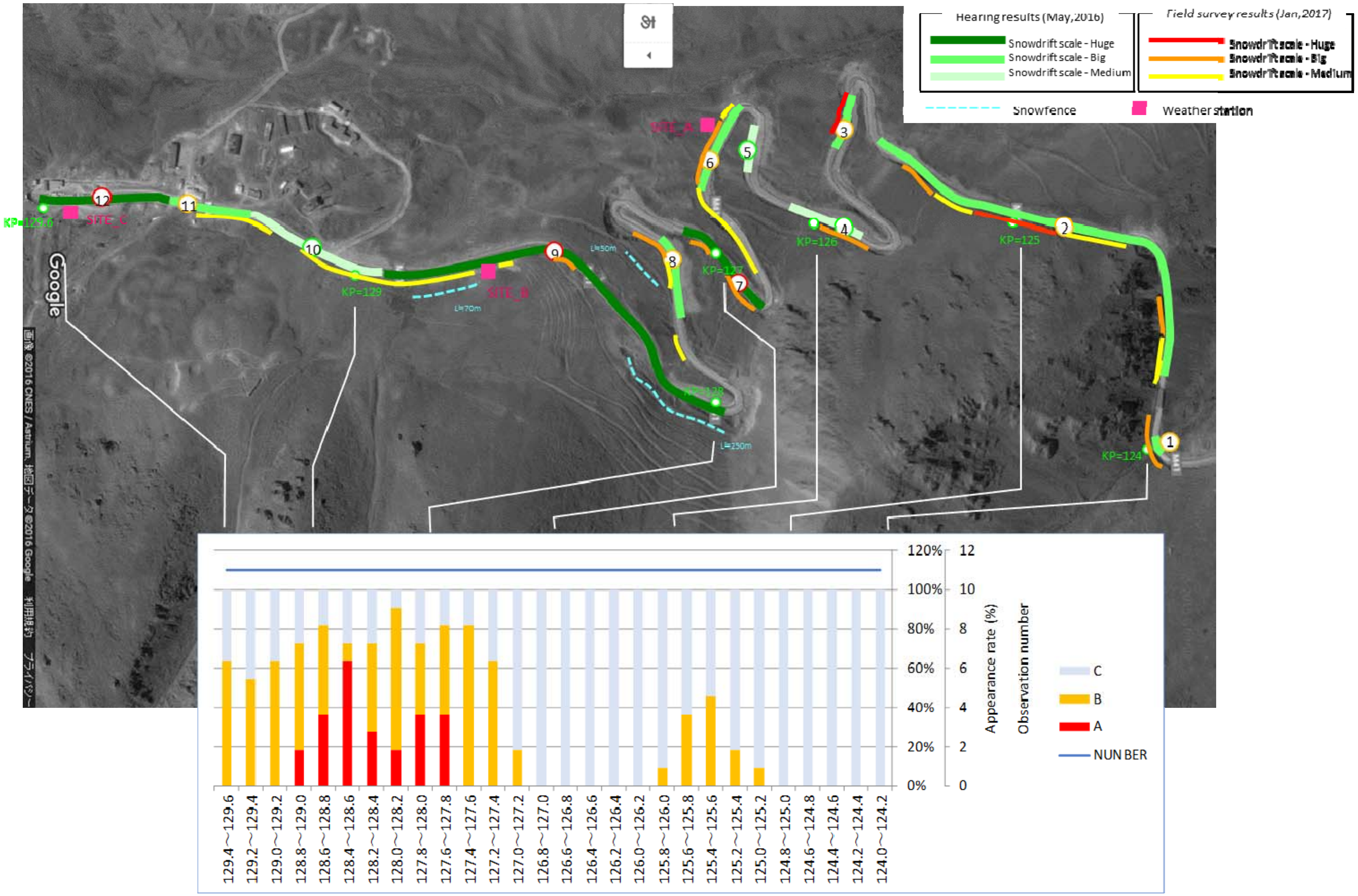


Figure 3.4.2 Example of snowdrift inspection results overwrite (2016-2017: Too-Ashuu pass: snow accumulation)