Development and Field Practice of Several Inspection Systems with Tablet Computer for Local Government and Developing Country

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1. Abstract of Inspection Systems with Tablet Computer

EASY and EFFICIENT

Inspection data input system with tablet computer used in worldwide

Outline of database system with tablet computer

Server computer
(in NIT, Nagaoka College, Japan)

Clients : tablet computer

Wi-Fi internet connection

On line / **Off line** use

Mac computer
+ Mac OS X
+ FileMaker Server

iPad (Wi-Fi model)
+ FileMaker Go

Wired network

Windows
+ FileMaker Pro

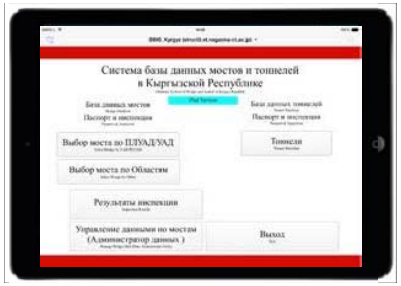
Maintenance PC

On line version
Advantage
- Result reflected in real-time

Off line version
Advantage
- Use in out of mobile communication area
- Quick and smooth operation

→ **Off line version** in main use

2. Development of bridge inspection and data browsing system by using tablet computer for Kyrgyz Republic (2014-2015)



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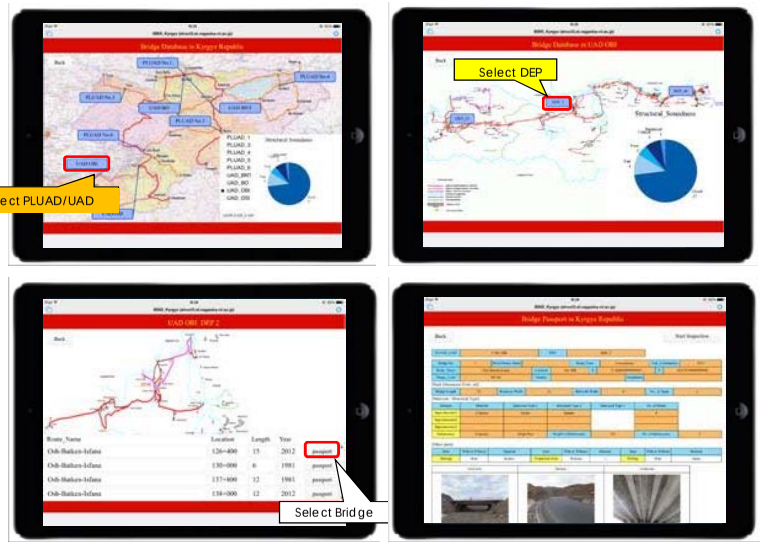
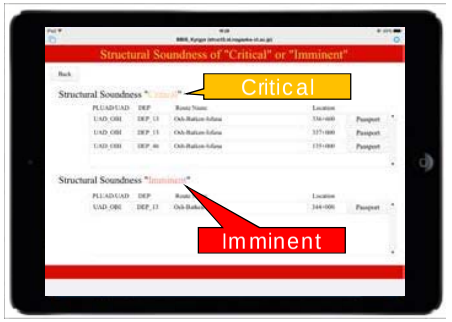
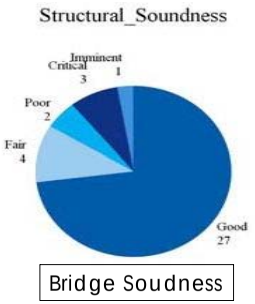
Bridge Data System

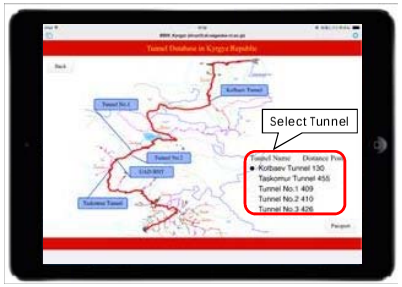


Bridge Data System





Tunnel Data System



3. Development and Trial of a Bridge Inventory and Inspection System with a Tablet Computer for Cambodia (2015-2017)

長岡工業高等専門学校
National Institute of Technology, Nagaoka College

Cambodia

- Bridges are deteriorating
- Bridge data is not collected

Development of a bridge inventory and inspection system with a tablet computer

Bridge Inventory System

The system Includes over 4 pages

【Items】

- Bridge length
- Constructed year
- Material type
- Photos
- Location information

etc.

In order to avoid wrong input

➡ Adopted multiple choices for some limited choices

Input photos and comments at once

➡ Create a bridge inventory efficiently

Bridge Inspection System

Trial

This system has been put in practice since July 2015

About 1700 bridges (during 2 months)
2400 bridges (during 1 year)
are collected

Collected Bridge Data from the system

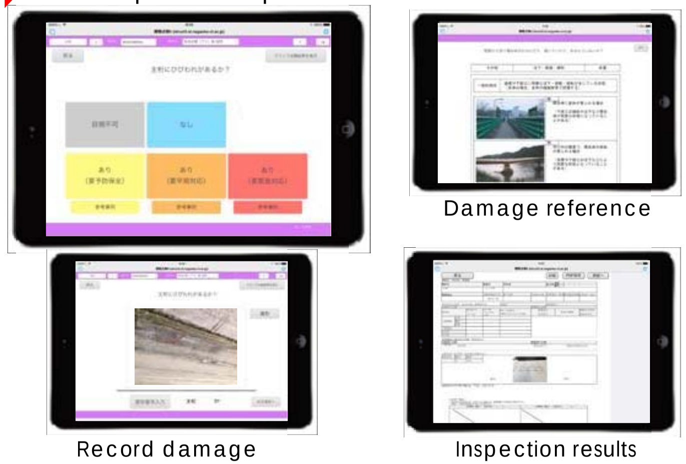
RA10-3

4. Study on practical applications of bridge brief inspection system in Niigata City, JAPAN with tablet computer (2017-2018)

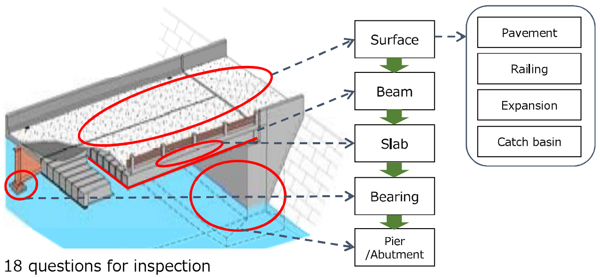
Overview

Bridge inspection cost is too expensive (about 100,000yen/1bridge)

Small bridge inspected by member of construction company, not inspection expert



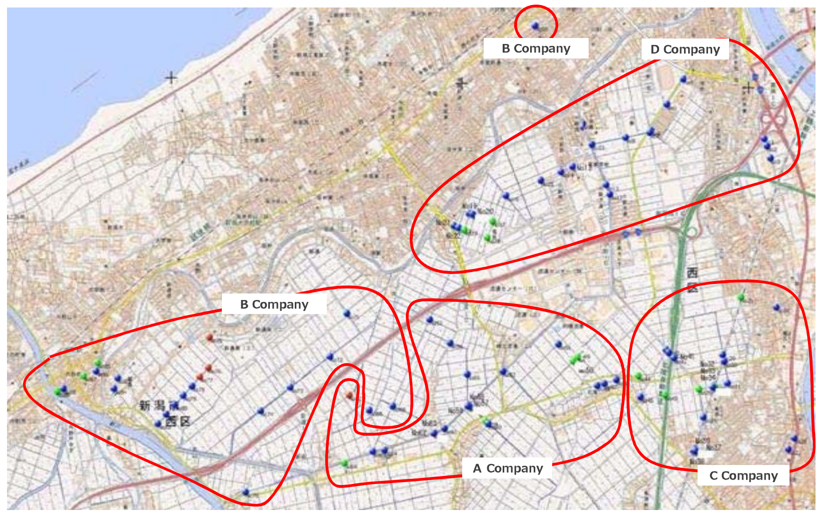
Inspection Procedure



18 questions for inspection

レイアウト番号	部材種類	点検内容	点検の選択肢					
			部材なし	目視不可	なし	あり（予防）	あり（早期）	あり（緊急）
1	橋全体	側面から見て橋全体がたわんだり，傾いていたり，ゆがんでいないか？			なし			あり（要緊急対応）
2	舗装	舗装面に，著しいひびわれやうき，ポットホール，水や石灰分の滲出などがあるか？	部材なし	目視不可	なし	あり（要予防保全）	あり（要早期対応）	
3	高欄・防護柵・地覆	高欄・防護柵・地覆に大きな変形，錆び，歩行者に危険と思われる箇所があるか？	部材なし	目視不可	なし	あり（要予防保全）	あり（要早期対応）	
4	伸縮装置	路面に異常な段差や凹凸が生じている状態であるか？	部材なし	目視不可	なし	あり（要予防保全）	あり（要早期対応）	
5		桁間の間隔や，伸縮装置及び支承に変異や遊間に異常が見られる状態であるか？	部材なし	目視不可	なし	あり		
6	排水桝	排水ますが詰まっているか，排水管が壊れていて落下のおそれがあるか？	部材なし	目視不可	なし	あり		
7	主桁	主桁にひびわれがあるか？	部材なし	目視不可	なし	あり（要予防保全）	あり（要早期対応）	あり（要緊急対応）
8		主桁にはく離や鉄筋の露出があるか？	部材なし	目視不可	なし	あり（要予防保全）	あり（要早期対応）	
9		主桁に遊離石灰や漏水があるか？	部材なし	目視不可	なし	あり		
10	床版	床版にひびわれがみえるか？	部材なし	目視不可	なし	あり（要予防保全）	あり（要早期対応）	あり（要緊急対応）
11		床版にはく離や鉄筋の露出があるか？	部材なし	目視不可	なし	あり（要予防保全）	あり（要早期対応）	
12		床版に遊離石灰や漏水があるか？	部材なし	目視不可	なし	あり		
13	支承	支承が錆びていたり，本体や基部のコンクリートが壊れているか？	部材なし	目視不可	なし	あり（要予防保全）	あり（要早期対応）	
14		支承に土砂が堆積しているか?	部材なし	目視不可	なし	あり		
15	下部構造	橋脚・橋台に洗掘があるか？	部材なし	目視不可	なし		あり（要早期対応）	あり（要緊急対応）
16		橋脚・橋台にひびわれがみえるか？	部材なし	目視不可	なし	あり（要予防保全）	あり（要早期対応）	あり（要緊急対応）
17		橋脚・橋台にはく離や鉄筋の露出があるか？	部材なし	目視不可	なし	あり（要予防保全）	あり（要早期対応）	
18		橋脚・橋台に遊離石灰や漏水があるか？	部材なし	目視不可	なし	あり		

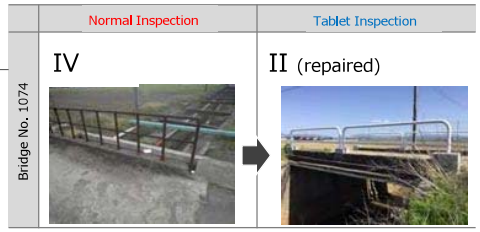
Inspection bridge map (90 bridges) by 4 construction company



"Normal Inspection" Inspected by inspection expert (member of construction consultant) in 2015
"Tablet Inspection" inspected by member of construction company in 2017

Tablet Inspection \ Normal Inspection	Ⅰ	Ⅱ	Ⅲ	Ⅳ	合計
Ⅰ	194	5	0	0	199
	68.3%	1.8%	0.0%	0.0%	70.1%
Ⅱ	64	14	4	1	83
	22.5%	4.9%	1.4%	0.4%	29.2%
Ⅲ	2	0	0	0	2
	0.7%	0.0%	0.0%	0.0%	0.7%
Ⅳ	0	0	0	0	0
	0.0%	0.0%	0.0%	0.0%	0.0%
合計	260	19	4	1	284
	91.5%	6.7%	1.4%	0.4%	100.0%
不	24	1	0	0	25

Zone 1	(Perfect matching !)	73.2%
Zone 2	(Worse result of Tablet Inspection)	23.2%
Zone 3	(Worse result of Normal Inspection)	3.2%
Zone 4	(Major difference)	0.4%



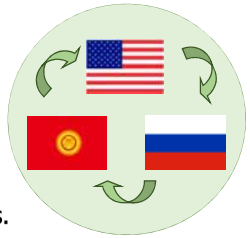
Reducing inspection cost about 1/5~1/10

5. Construction of database for road disaster prevention using tablet computer in Kyrgyz Republic (2016-2018)

長岡工業高等専門学校 National Institute of Technology, Nagaoka College

This database can accumulate accumulation and the disaster record of the data of the disaster dangerous point.

The language in this system is three languages.



Road disaster prevention database

Data are collected about six disaster types

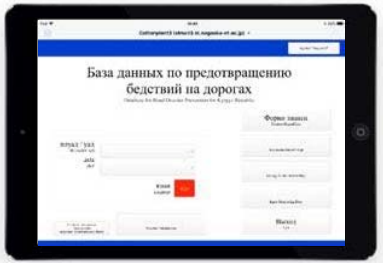
"Falling Rocks/Bedrock Collapse"
"Slope Collapse/Landslide Collapse"
"Debris Flow"
"Avalanche"
"Snow Drifting"
"Slope/Riverbank Erosion"

Falling Rocks/ Bedrock Collapse

Slope Collapse/ Landslide Collapse

Riverbank Erosion

Result and significance



In a periodical patrol in Kyrgyz republic, can check and the measures of the road of the point with the possibility of the disaster outbreak are relatively easily performed

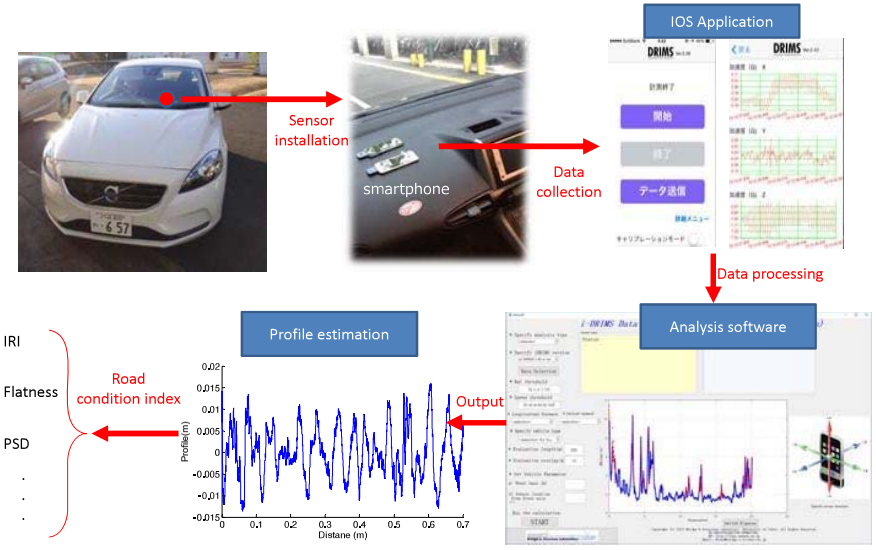
RA10-5

RA11-1

Development of road condition evaluation system using a smartphone

Tomonori NAGAYAMA
Associate professor
Department of Civil Engineering
The University of Tokyo

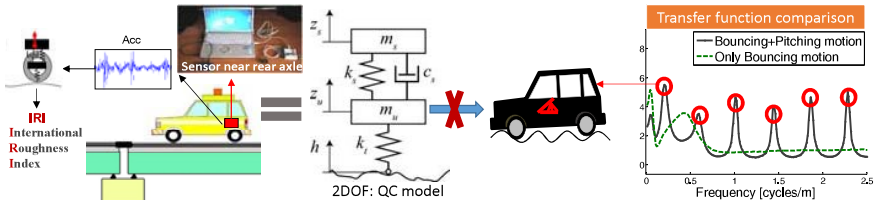
DRIMS (Smartphone-based DRIMS) outline



Vehicle modeling

Existing road condition evaluation method:

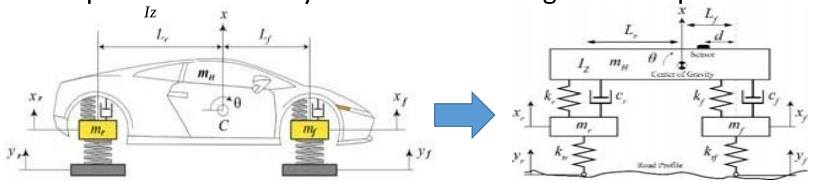
Mechanism	Method	Cost	Easily applicable	Model	Sensor Location	Target
Laser-based	Profiler	**High**	**No**	-	-	Profile
Response based	DRIMS (PC)	Low	Yes	2DOF	**above axle**	IRI
	DRIMS（Smartphone)	Low	Yes	4DOF	Anyplace	Profile



Main Drawback of PC-DRIMS (old version) and other response-based approaches: Quarter Car (QC) model cannot simulate vehicle pitching motion; innacurate.

DRIMS (smartphone based DRIMS)

- Half car model based : account for bouncing+pitching+axle motions
- Profile estimation : obtain the road profile directly
- Smartphone based : easy installation and large-scale implementation



Half car model

However, response based road condition evaluation using half car (HC) is difficult to calibrate vehicles. Only vehicles 1) already calibrated at laboratories or 2) with automaker parameters have been used for HC research

Method	Target	Applicable for ordinary vehicle
González (2008)	**Road PSD**	**No**
Ngwangwa(2014)	Road Profile	**No**
DRIMS	Road Profile	Yes

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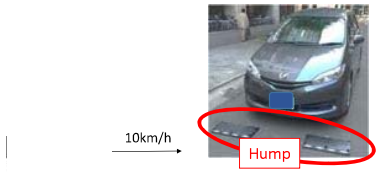
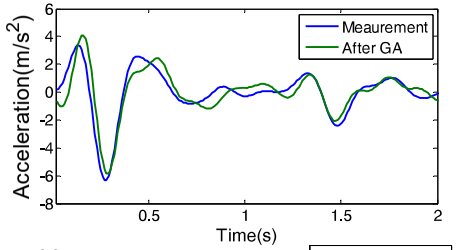
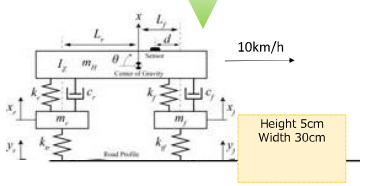
Vehicle modeling with 4 DOF

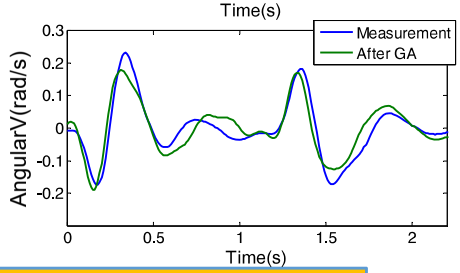
Hump calibration





Simulated by Half car model





The vehicle is modeled as a half-car model using hump passage responses

Profile estimation

State-space model

Vehicle dynamics

System eq. $\mathbf{x}(k+1) = \mathbf{A}\mathbf{x}(k) + \mathbf{v}(k)$

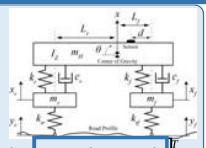
Observation eq. $\mathbf{y}(k) = \mathbf{C}\mathbf{x}(k) + \mathbf{w}(k)$

$\mathbf{x} = [x \;\; \theta \;\; x_f \;\; x_r \;\; \dot{x} \;\; \dot{\theta} \;\; \dot{x}_f \;\; \dot{x}_r \;\; y_f \;\; \dot{y}_f \;\; y_r \;\; \dot{y}_r]^T$

$\mathbf{y}(k) = [\ddot{x} \;\; \ddot{\theta}]^T$

Profile (unknown)

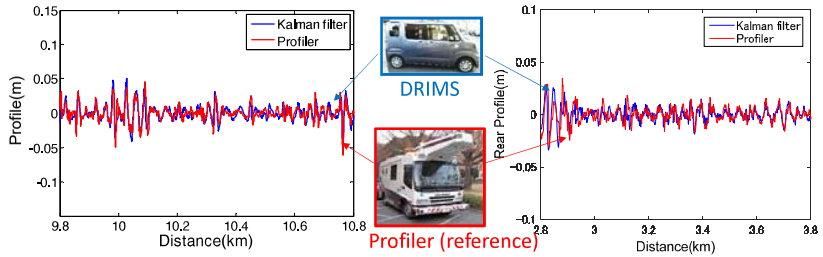
Profile estimation through Kalman Filter



feature :

- Kalman Filter with a HC model
- acceleration (vertical +longitudinal) & **pitching anular velocity**
- Drive speed change is compensated

Profile estimation using DRIMS and profiler (0.02—0.5cycle/m)



DRIMS gives profile estimation which is consistent with the profiler

Experimental validation of IRI estimation

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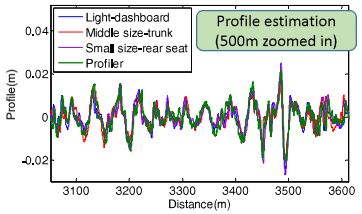
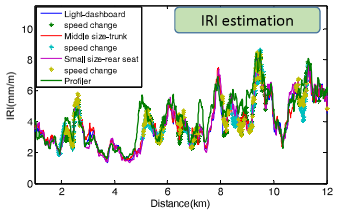
Three types of vehicles

Light type | Small size | Middle size(Van)

Reference (Profiler)

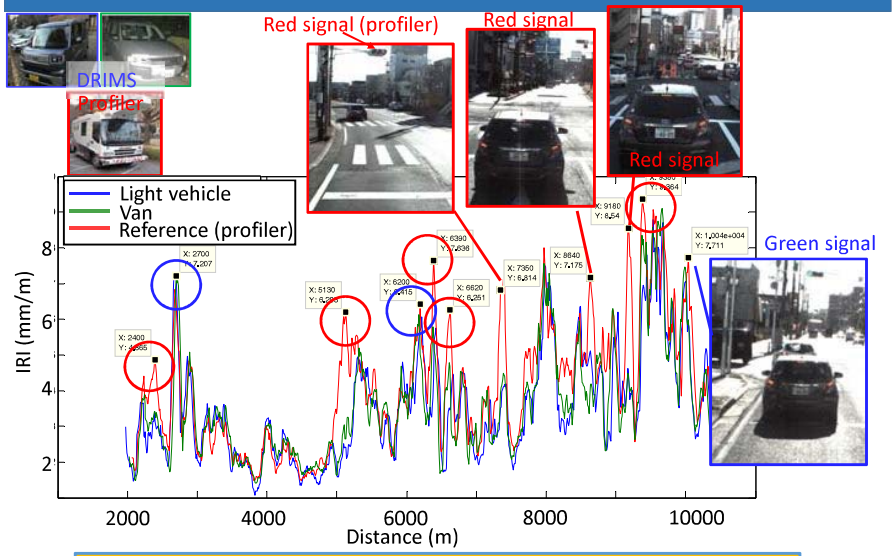
Test course: 13.6 km in Chiba-city





IRI estimation error is 10 %

IRI estimation accuracy based on profile estimation



DRIMS performs even better than the profiler at start/stop sections

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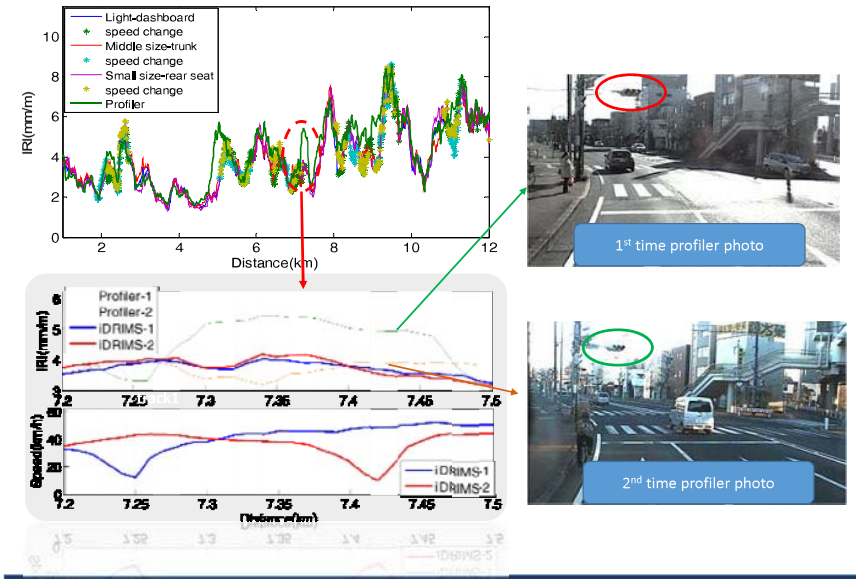
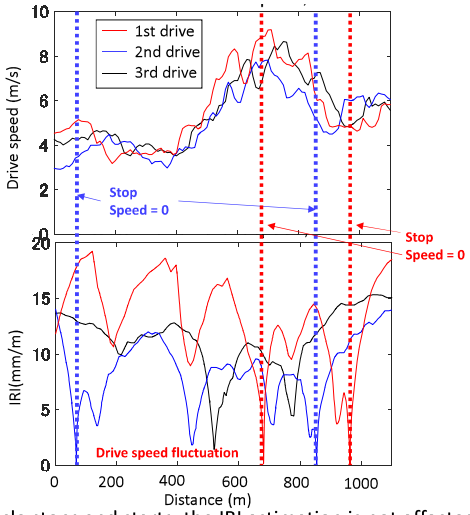
Experiment validation of profile estimation



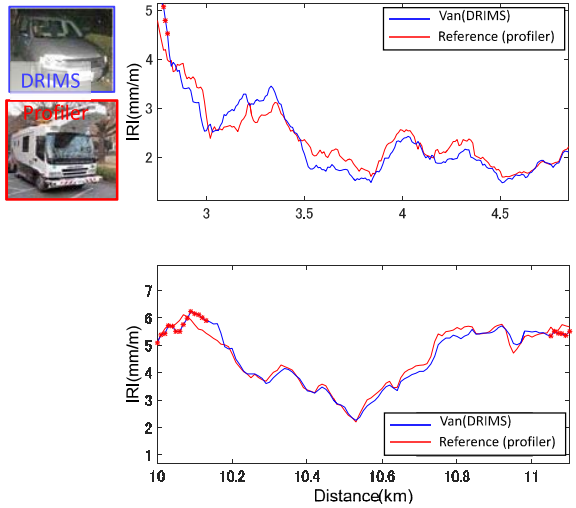
Robustness against speed fluctuation and stop/start

3-time repeated measurement with various speed pattern



- Even when the vehicle stops and starts, the IRI estimation is not affected much.
- The effect of drive speed fluctuation is small.

IRI estimation accuracy at good measurement condition



When drive speed is almost constant, the DRIMS and profiler gives almost identical IRI.

Performance Evaluation Test at Public Works Research Center (PWRC)

DRIMS performance:

Flatness	3m profile meter	DRIMS	Error	Length
Section 1	0.90-1.03mm	1.08mm	4.85%	100m
Section 2	0.99-1.07mm	1.02mm	0.00%	100m
Section 1+2	0.88-1.01mm	1.05mm	-3.96%	200m

IRI	Leveling	DRIMS	Error	Length
Section 1	1.27mm/m	1.41mm/m	11.02%	100m
Section 2	1.50mm/m	1.32mm/m	-12.00%	100m
Section 1+2	1.39mm/m	1.37mm/m	-1.44%	200m

The **only smartphone- based road evaluation method** in Japan, which successfully obtained this certificate when installed on an ordinary car.

Large-scale implementation

Large-scale implementation

DRIMS has been implemented on commercial vehicles.

- About 100 commercial vehicles, about 10 organizations
- More than 1 year data
- Data collection/analysis visualization platform to handling a large amount of data
- Based on GPS data, the IRI values are mapped to road map.
- Data is centrally managed. Vehicles actively used, inactive vehicles, vehicles with calibration problems can be centrally examined.

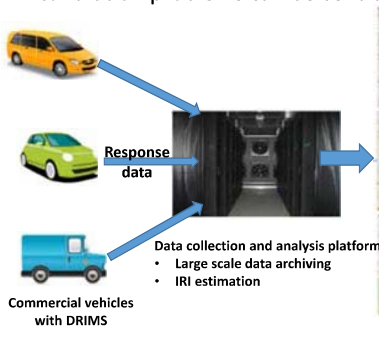
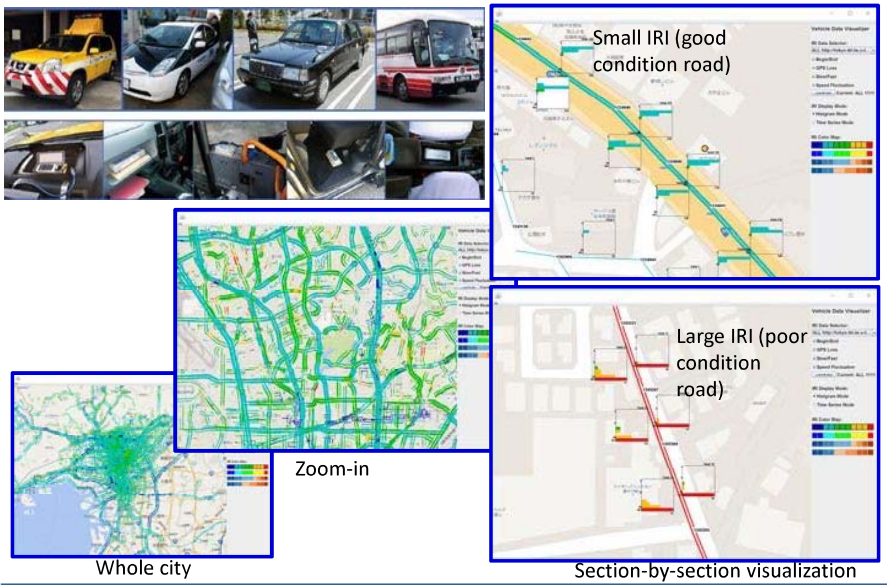


Fig. Display road condition with a heat map

(Provided by: Masashi Toyoda, Institute of Industrial Science, the University of Tokyo)

Large-scale interactive visualization



Large-scale interactive visualization

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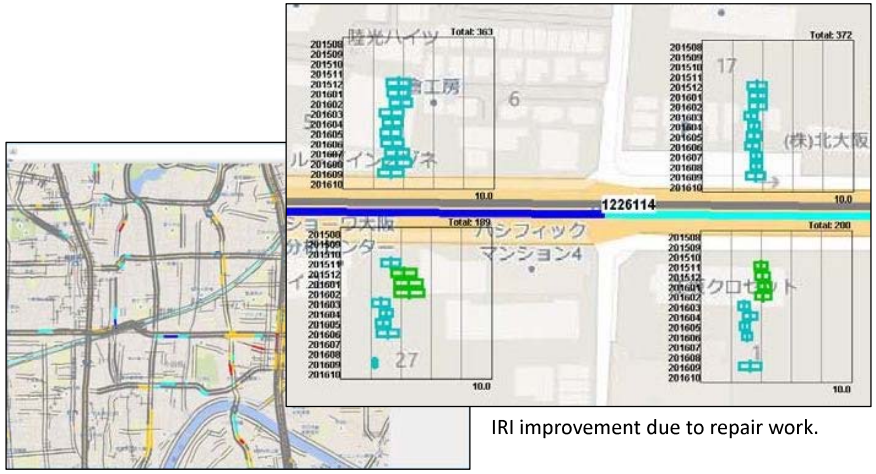
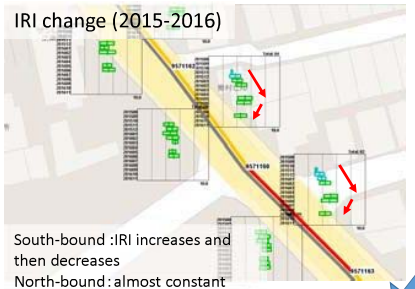
Large-scale interactive visualization (chronological change)



IRI improvement due to repair work.

Large chronological changes are high-lighted.

Large-scale interactive visualization (chronological change)



South-bound :IRI increases and then decreases
North-bound : almost constant

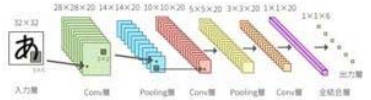
Difference captured due to the high accuracy/frequent measurement.

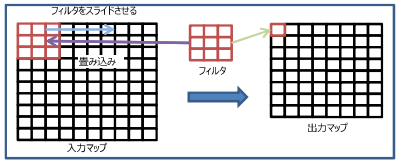
Image processing using deep learning

SIP 19

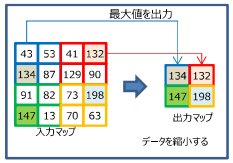
Deep learning

- 畳み込みニューラルネットワークの手法を中間層に使用
- 画像の局所的な特徴を抽出する畳み込み層と局所的な特徴をまとめるプーリング層を繰り返した構造



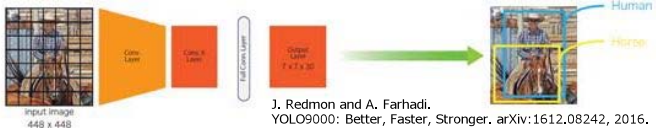


convolution



pooling

Network model : YOLOv2(ECCV2016)



J. Redmon and A. Farhadi.
YOLO9000: Better, Faster, Stronger. arXiv:1612.08242, 2016.

福井 宏, 山下 隆義, 山内 悠嗣, 藤吉 弘亘 :
Deep Learningを用いた歩行者検出の研究動向, 信学技報, 2016.

Deep learing

SIP 20

Training data categories and the sample numbers

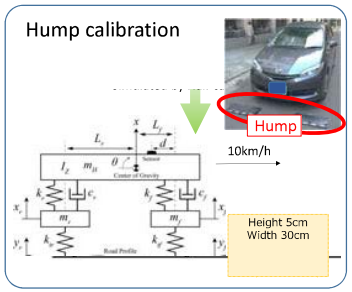
Linear crack	alligator crack	Manhole	joint	patch	Side ditch lid	White line (short)	White line (long)	total
1,197	698	570	398	613	247	418	444	4,585

accuracy

区間 —— : 179号線海田西町～263号線倉吉駅前～21号線 4.1km
—— : 201号線倉吉駅裏 0.4km

	Linear crack	Alligator crack	manhole	joint	patch
samples	726	45	233	16	95
Accuracy rate	89%	93%	94%	69%	55%
False negative	11%			31%	44%

Removal of the necessity of Hump calibration



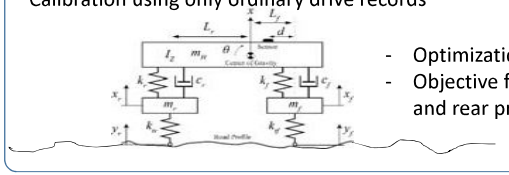
- Important to compensate the difference among different vehicles.

However,

- A set of humps of specific shape needs to be prepared. Obtaining humps may involve import procedures/ takes long time.
- A flat surface road for the hump calibration is needed.
- The drive conditions during the hump test are not necessarily the same. The calibration results depends on the way how the driver operates the vehicle.

=> Vehicle parameter identification without the hump test is needed.

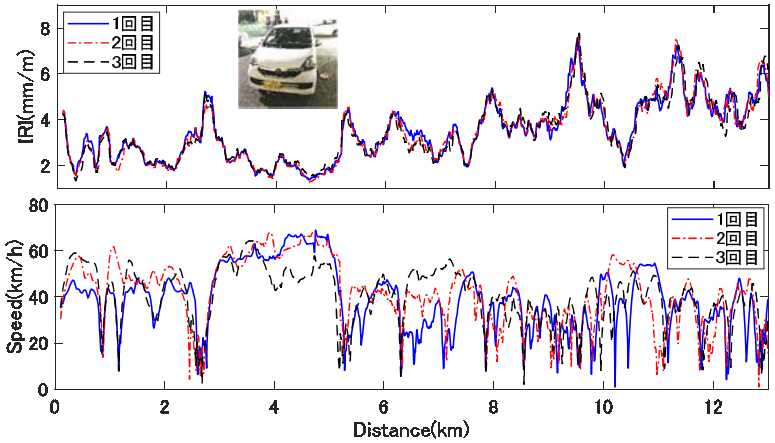
Calibration using only ordinary drive records



- Optimization of 10 vehicle parameters.
- Objective function: Difference between the front and rear profile identified independently.

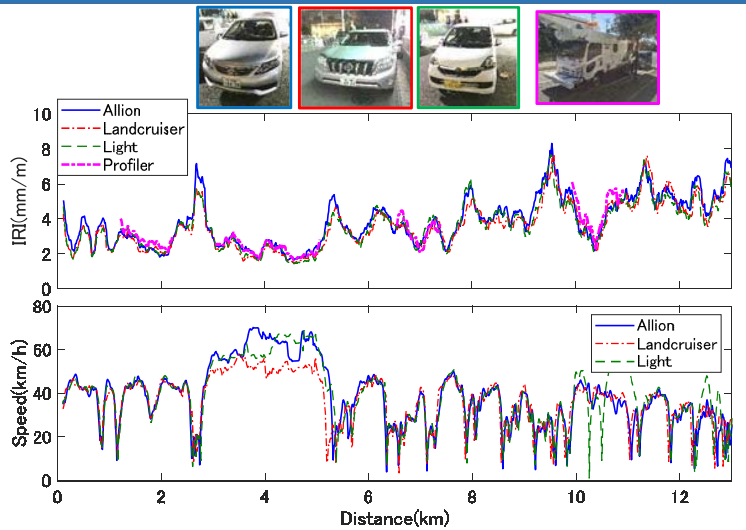
IRI estimation without hump calibration: Repeatability

Drive tests were repeated three times with different speeds.



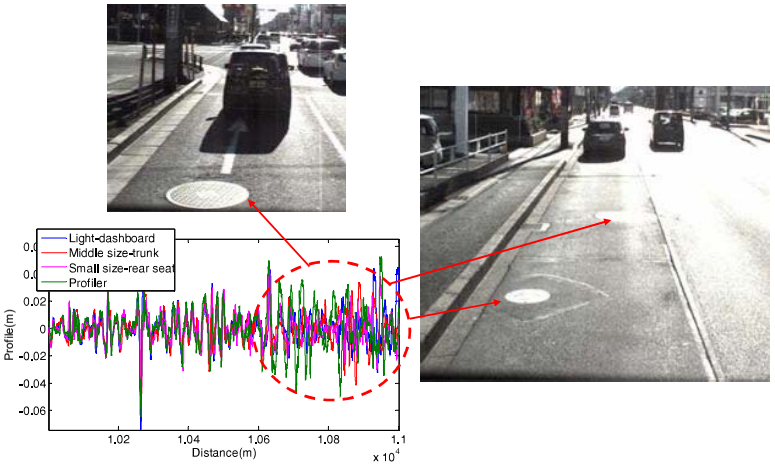
Almost identical IRI is obtained even when drive speeds are different.

IRI estimation without hump calibration: Different vehicles



Estimated IRI are consistent among the three vehicles and the profiler.

Limitation of HC model based profile estimation method

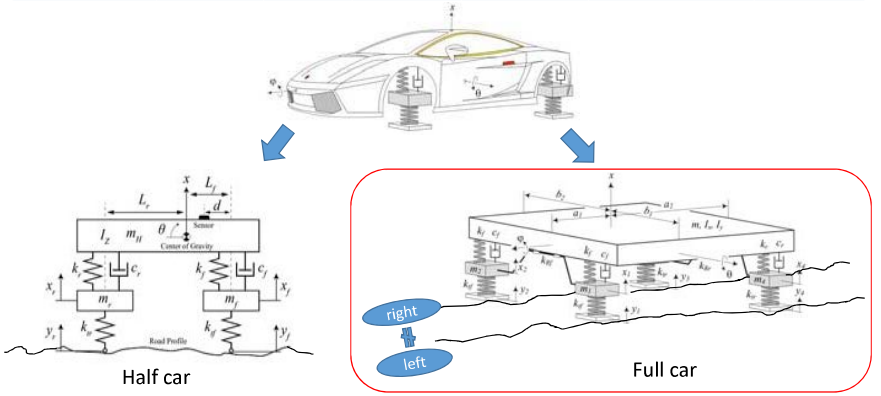


Accuracy of HC model-based method is affected by the difference between left and right path

Full car model & Half car model

Full car & half car model comparison

	Bouncing	Pitching	Rolling	Number of parameter	Inputs	Degree of freedom
Full car model	○	○	○	16	4 (four tires)	7
Half car model	○	○	×	10	2 (front&rear tire)	4



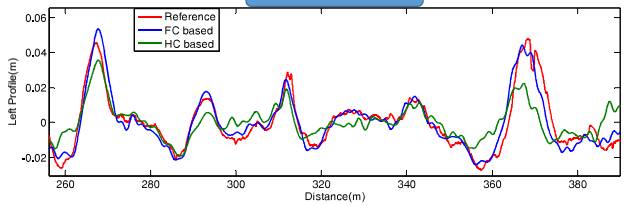
Experiment validation

Target road (730m)

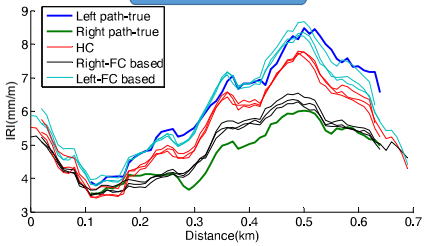
- Target road in Saitama, different roughness between left and right path
- True profile is measured by road profiler cart

Experiment validation

Profile (Zoomed in)



3 times IRI results



IRI relative error

Model	Times	Left path	Right path
HC based (left sensor)	1st	16.5%	41.1%
	2nd	16.3%	40.9%
	3rd	15.9%	40.0%
FC based	1st	5.4%	11.8%
	2nd	5.2%	9.6%
	3rd	4.2%	9.1%

IRI of both left and right paths are accurately estimated using the FC model

Conclusion

- A smartphone-based road condition evaluation system has been developed.
  - ✓ Easy installation
  - ✓ Accurate sensing, vehicle calibration, and profile estimation

- The system has been implemented on commercial vehicles in Japan. The vehicle data is collected in large-scale. The estimated results are mapped to roads. Data is managed centrally at a server.

- The system has been further improved for 1) removing the necessity for the hump calibration and 2) full-car model.

Japan International Cooperation Agency (JICA)

Ministry of Transport and Communications Kyrgyz Republic

THE PROJECT FOR CAPACITY DEVELOPMENT FOR ROAD DISASTER PREVENTION MANAGEMENT IN THE KYRGYZ REPUBLIC

Workshop for Slope/ Flood/ Erosion Disaster

Table of Contents

IC1-1

1. Outline of the Project

Overall Goal

Safety of the road traffic at the selected disaster prone areas is improved.

Project Purpose

The capacity of MOTC's relevant units in the Project (HQ, RMD, target PLUADs/UADs, and DEPs) is enhanced for management of road disaster prevention (including road disaster inspection, preparing of road disaster prevention management plan and planning of budget for road disaster prevention).

1. Outline of the Project

【Output-1】
Responsibilities of MOTC on road disaster prevention, including specific duties to be performed by relevant units (HQ, RMD, target PLUADs/UADs, and DEPs) with necessary staffing in each, become clear.

【Output-2】
Capacity of target PLUADs/UADs and DEPs for inspection and analysis of road disaster is enhanced.

【Output-3】
Capacity of RMD to operationalize Database Management System for road disaster prevention is developed.

【Output-4】
Capacity of RMD for preparing road disaster prevention management plans of the target areas is enhanced.

2. Existing Record & Inspection for Road Disaster

Existing Record for Road Disaster

【Immediate Aftermath of Disaster】

Item/Contents	Date, Member of Inspection(Name, Position), Name of the road, Distance Mark, Disaster Type, Proposed Recovery Work, Damage Volume (Qty., Unit Cost, Total Cost)
Common Form	Existing
Role/ Responsibility	Prepared by DEP (Technical Department) → UAD/PLUAD → RMD → MES, Local Government Units (LGUs) Required Signature of MES's &LGUs' Representative

【Quarterly Period】

Item/Contents	Name of the road, Distance Mark, Date, Disaster Type, Proposed Recovery, Damage Volume (Qty., Cost), Actual Executed Recovery (Unit, Qty., Cost)
Common Form	Existing
Role/ Responsibility	Prepared by DEP → UAD/PLUAD → RMD

2. Existing Record & Inspection for Road Disaster

Existing Record for Road Disaster

【Road Traffic Record】

Item/Contents	Name of the road, Distance Mark, Date, Disaster Type, Type of Temporary Work (like Cleaning Work), Type of Equipment, Number of Equipment, , Traffic Condition (like Time/Duration of Temporary Traffic Blocked, Method of Traffic Control)
Common Form	Non-Existence
Role/ Responsibility	Prepared by DEP (Road Safety Department) → UAD/PLUAD → RMD → Police → MIA Required Signature of MES's Representative

2. Existing Record & Inspection for Road Disaster

Existing Inspection for Road Disaster

【Daily Inspection】

Item/Contents	Depend on DEP in charge of inspection
Common Form	Non-Existence
Role/ Responsibility	DEP → UAD/PLUAD

【Periodic Inspection in Spring and Autumn-1 (General)】

Item/Contents	Date, Name of Road, Distance Mark, Member of Inspection, problem/issue, proposed rehabilitation, implementation date
Common Form	Existing
Role/ Responsibility	Prepared by DEP → MIA, UAD/PLUAD → RMD Required Signature of MIA's Representative

How do you select the location of inspection? What is the criteria?

2. Existing Record & Inspection for Road Disaster

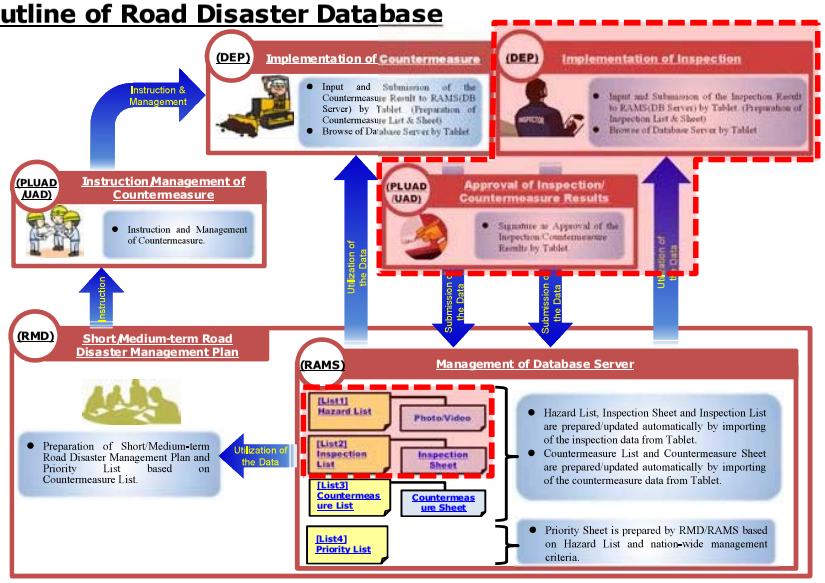
Existing Inspection for Road Disaster

【Periodic Inspection in Spring and Autumn-2 (Specified)】

Item/Contents	(1st Page) Name of Road, Distance Mark, Classification/Category of Road, Average Daily Traffic Volume, Number of Traffic Accident, Number of casualty, Traffic Safety Index, Final Accident Index, Accident Rate index (2nd Page) Implementation for Improvement (Proposed Location, Target Date and Estimated Cost) Commencement & Completion Date for Regular Inspection at Hazardous Area, Sketch at Hazardous Area
Common Form	Existing
Role/ Responsibility	Prepared by DEP → UAD/PLUAD, Police

3. Proposed Record & Inspection for Road Disaster

Outline of Road Disaster Database



3. Proposed Record & Inspection for Road Disaster

Proposed Record for Road Disaster to Save in Database

Purpose	• To Select Countermeasures and Priority Project • To Prepare Hazard Map
Frequency	Immediate Aftermath of Disaster
Item/Contents	• Disaster Type • Location (Name of Road, Distance Mark) • Occurrence Date • Duration of Traffic Regulation & Cleaning (hrs.) (Whole Lanes, One Side lane, Without Regulation (but cleaning at road shoulder)) • Human/Vehicle Damage (Nos.) (Decease, Serious injury, Slight injury, Vehicle Damage, Nothing) • Weather Condition at Occurrence (After Rain, Snow Melt, Snow Cover, Dry Snow, Wet Snow, Visibility during Snowdrift (m), Depth of Snowdrift (cm), Others) • Debris/Snow on Road (Length (m), Max. Depth (m)) • Other Damage (w/dimension) • Actual executed Disaster Recovery (Method, Unit, Qty., Total Cost, Executed Date) • Name of Person (input by:)
Role/ Responsibility	Input by DEP → Approved by UAD/PLUAD → RMD

3. Proposed Record & Inspection for Road Disaster

Proposed Inspection for Road Disaster to Save in Database

Purpose	• To Select Temporary and Permanent Countermeasures • To Prepare Hazard Map
Frequency	Twice a Year (In Spring and Autumn)
Item/Contents (Common)	Name of Road, Distance Mark, Date, Name of UAD/PLUAD, Name of DEP, Photo, Comments, Name of Person
Item/Contents (Rockfall)	Slope Condition, Condition of Spring Water, Condition of Vegetation, Slope Gradient, Slope Height
Item/Contents (Landslide)	Slope Condition, Terrain, Condition of Spring Water, Slope Gradient, Slope Height
Item/Contents (Debris Flow)	Stream/Spring, Width of, Main Materials of Streambed, Condition of Causeway, Drainage Pipe/Culvert under the Road, Condition of Drainage at Valley Side
Item/Contents (Avalanche)	Snow Depth, Slope Gradient, Condition of Vegetation, Slope Azimuth, Slope Type
Item/Contents (Snowdrift)	Snow Depth, Temperature, Wind Velocity, Condition of Vegetation, Terrain
Item/Contents (Slope /Riverbank Erosion)	Slope Gradient, Slope Height, Condition of Slope Protection, Scale of Erosion, Place of Erosion on Slope, Influence on Carriage Way
Role/ Responsibility	Input by DEP → Approved by UAD/PLUAD → RMD

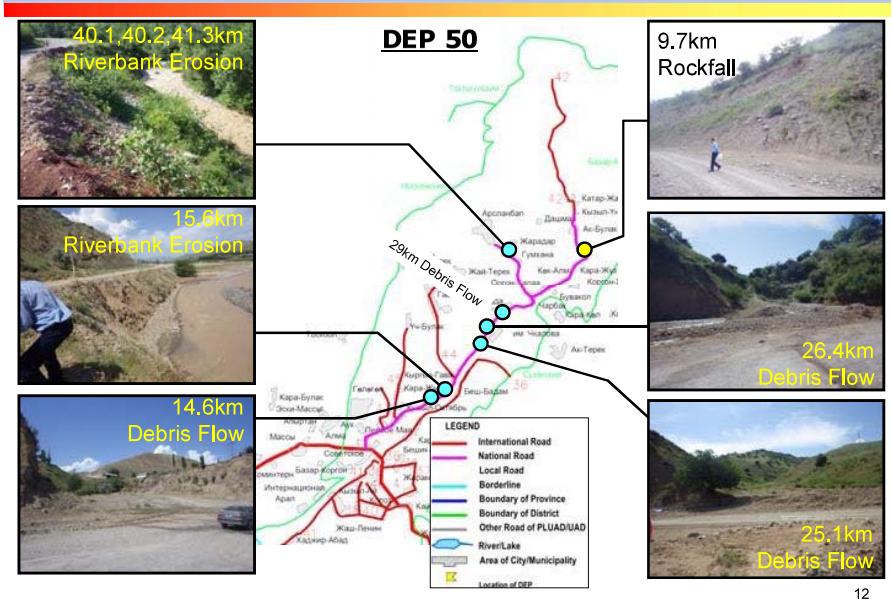
4. Annual Budget for Road Disaster (Rehabilitation Cost)

Type of Disaster	Number of Rehabilitation			Actual Rehabilitation Cost (Thousand Soms)			Main Activities for Rehabilitation
	2013	2014	2015	2013	2014	2015	
Talus and Rockfall	4	1	4	422	289	3,500	Cleaning, Restoration
Landslide	6	8	9	1,889	2,921	2,395	Cleaning, Restoration
Mudflow	75	32	44	34,859	5,522	10,417	Cleaning, Restoration
Flood	39	17	39	8,658	10,705	18,347	Restoration of roadbed, bridge and other structure
Avalanche	9	22	8	3,966	4,402	3,251	Cleaning
Snowdrift	6	1	4	164	100	1,318	Cleaning
Others (Unenrolled and Unspecific)	2	2	12	72	54	2,458	-
Total	141	83	120	50,032	23,993	41,686	-

Data Source: MOTC

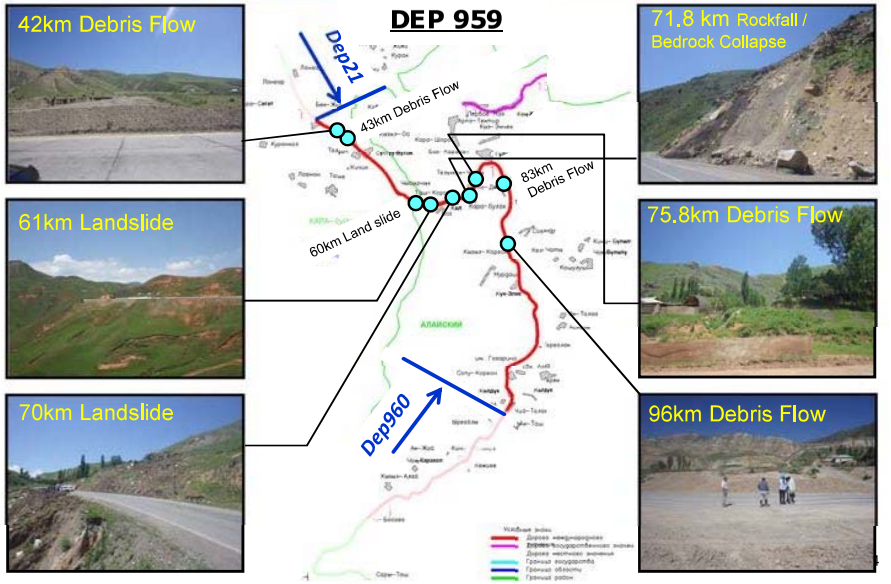
It is aimed that Countermeasures against road disaster is included in the budget of 2017

5. Location of Site Inspection



5. Location of Site Inspection

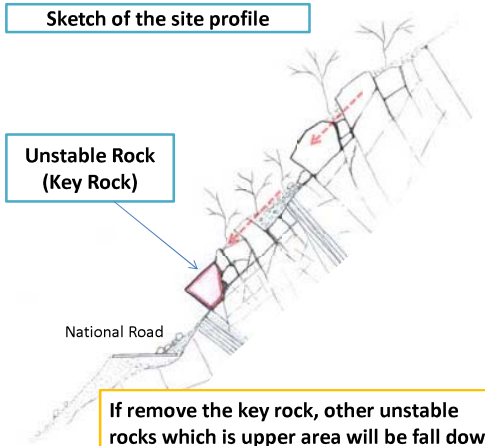
5. Location of Site Inspection



6. Site Inspection Result & Applicable Measures for Rockfall

Site Inspection Result and Applicable Measures of Rockfall (Myrzake-Karakuluja-Alaikuu, 48.4km: DEP26)

Sketch of the site profile



If remove the key rock, other unstable rocks which is upper area will be fall down. So we should have the countermeasure work which will fix the key rock.

Unstable rock mass

After the stability work in Japan (Using the wire protection net)

6. Site Inspection Result & Applicable Measures for Rockfall

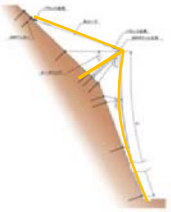
Typical Countermeasures against Rockfall/Bedrock Collapse(1/2)


Gabion wall for Rock fall (Bolivia, H=3.0m)
This type of construction is able to construct by domestic work in Kyrgyzstan. The construction site should be selected by rock fall frequency and the scale.

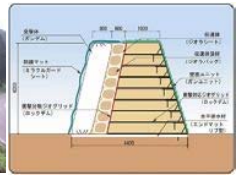

"Protection Fence" is the one of the countermeasure work for rock fall in Japan. This type of work is developed for high impact load of falling rock. The material of the fence can catch over 2.0m diameter rock from 50m height from the upper slope. For keeping the secure safety of the road, this type of work is necessary in Kyrgyzstan. It will need big budget.

6. Site Inspection Result & Applicable Measures for Rockfall

Typical Countermeasures against Rockfall/Bedrock Collapse(2/2)

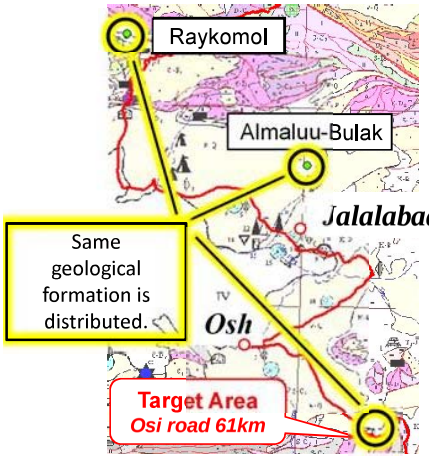
"Protection Net" is the one of the countermeasure work for rock fall in Japan. There are two types of this work. One is cover type and the other is pocket type. These types are used for properly by height and shape of the slope. Both type is applied for higher rock impact. But the cost of the high impact type will need big budget.

Reinforced soil wall is developed for huge rock fall impact in Japan. This type wall can catch over 2.0m diameter rock from 50m height. For keeping the secure safety of the road, this type of work is necessary in Kyrgyzstan. For constructing this countermeasure work, it will need big budget and enough space along the road.

7. Site Inspection Result & Applicable Measures for Landslide

Site Inspection Result of Landslide (OSI Road 61km: DEP959)

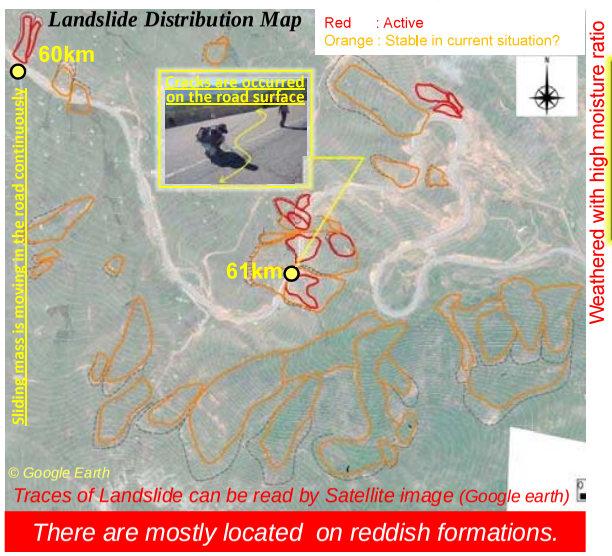


Target area is located on geological formation which **easily causes landslide**.

Information Source : American Geophysical Union

7. Site Inspection Result & Applicable Measures for Landslide

Site Inspection Result of Landslide (OSI Road 61km: DEP959)



There are mostly located on reddish formations.

Weathered with high moisture ratio
Fluidized

[Features of Reddish formations]
In the case of high water - retaining condition ,
it becomes easy to be ***fluidized***

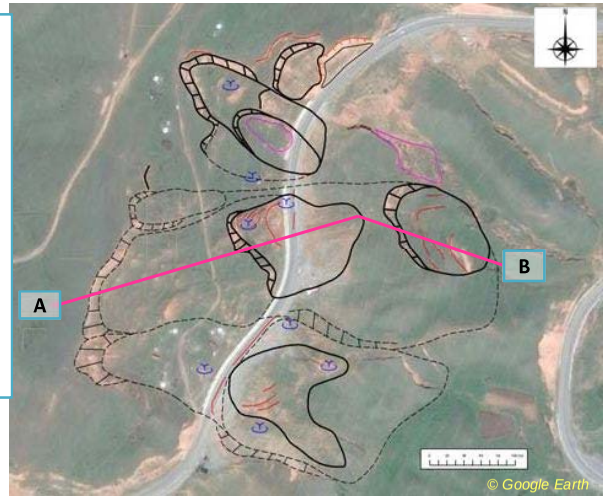
Easily causes landslide

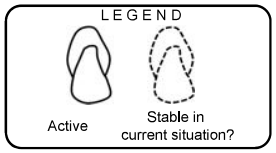
IC1-5

7. Site Inspection Result & Applicable Measures for Landslide

Site Inspection Result of Landslide (OSI Road 61km: DEP959)

This figure shows the unit of the landslide (= block) . There are many landslide blocks around this area. Width is 50 to over 200m for each block. Some of them moved ancient era. But some shallow blocks are moving now. Heavy rain and changing of underground water condition will move the landslides again. So we should take attention to this area.

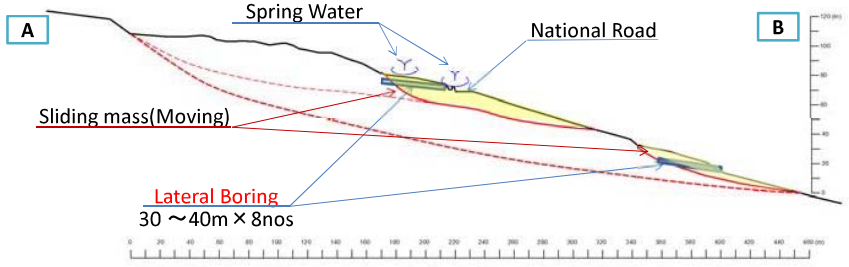




7. Site Inspection Result & Applicable Measures for Landslide

Applicable Measures for Landslide (OSI Road 61km: DEP959)

Remove the surface and underground water is the highest priority action for stabilizing the landslide. The Open Drainage Conduit which lead the surface water to outside of the landslide is necessary and effective work. The Lateral Boring is setting the drainage pipe into the landslide mass and lead the excess underground water to the outside. These work will decrease the moving speed of the landslide. But only using these method is not the perfect way to mitigate the landslide hazard. Using some types of countermeasure works for combination is usual. In Japan there are many types of countermeasure works which is selected by situation of the landslide.



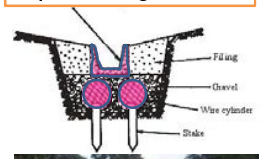
Lateral boring ; one of countermeasure work (profile A-B)

7. Site Inspection Result & Applicable Measures for Landslide

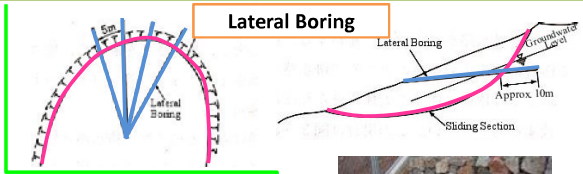
Applicable Measures for Landslide (OSI Road 61km: DEP959)

This area has following risk. If the essential big landslide will increase its activity, the national road will be broken away and the road traffic will be blocked for long time by monthly order. So we should prepare for the landslide risks.

Open Drainage Conduit



Lateral Boring



Gabion type

Concrete type

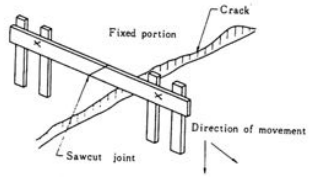
End portion of the drain pipe

Detail inspection is needed for determine the countermeasure work for landslide. Scale of moving area, depth of moving deposit, geologic condition and structure, monitoring for landslide activity and underground water , surface water, analysis for landslide mechanism. We recommend to continue monitoring for surface moving.

8. Site Monitoring Method for Landslide

Site Monitoring Method for Landslide (OSI Road 61km: DEP959)

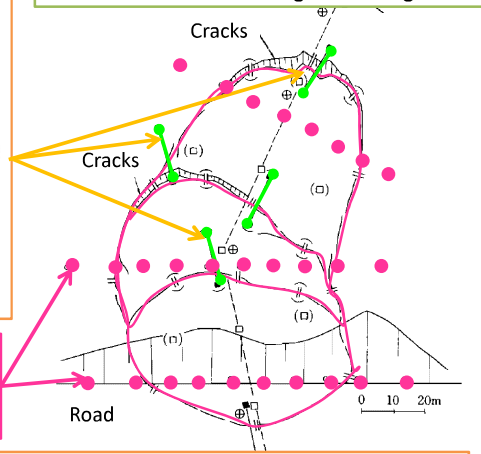
※Using the simple way



simplified method using displacement wood plates (stakes)
Crossing the moving crack
Check the moving periodically

Displacement stakes for straight line
Check the moving periodically

Placement of monitoring for moving area



Checking for difference of the amount of the spring water, new cracks, displacement of the structures(retaining walls, surface of the road, etc) is also important.

9. Site Inspection Result & Applicable Measures for Debris Flow

Site Inspection Result of Debris Flow: Myrzake-Karakulja-Alaikuu Road: 60.3km (DEP26)

Cross-Section

Mountain Side

Valley Side

- Debris Flow Disaster occurs every after rainfall. (Cleaning Work is required for 2hours)
- Traffic was blocked for 1 day and RC pipe was washed out on 18 May, 2016.

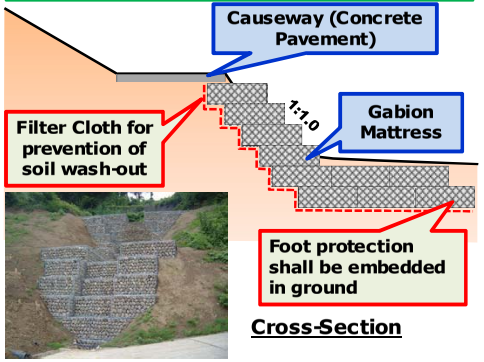
9. Site Inspection Result & Applicable Measures for Debris Flow

Applicable Measures for Debris Flow: Myrzake-Karakulja-Alaikuu Road: 60.3km (DEP26)

The followings are required to plan and design Sabo Dams
- Topographic/geotechnical survey
- Rainfall/snow melting analysis
- Sedimentation analysis
- Calculation of design discharge of debris flow
- Structural calculation of dam body and related facilities

Option-1: Sabo Dams/ Sediment Control Dams at Mountain Side

- Causeway and gabion mattress can be protected the road surface and shoulder.
- However, cleaning work on the road is still required after the debris flow occurred.
- The maintenance of gabion mattress is required due to debris flow.



Cross-Section

Option-2: Causeway and Gabion Mattress at Valley Side

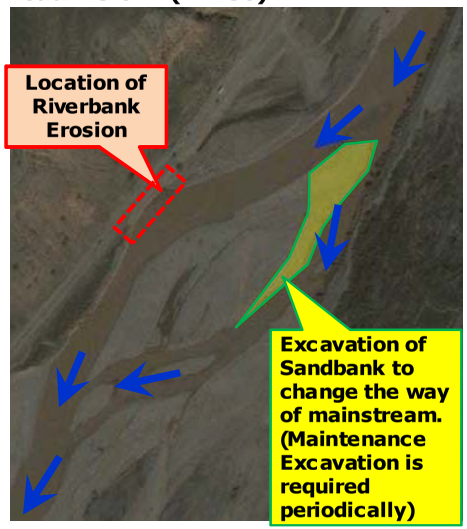
10. Site Inspection Result & Applicable Measures for Riverbank Erosion

Site Inspection Result of Riverbank Erosion: Bazar-Korgon-Arstanbap Road: 15.6km(DEP50)

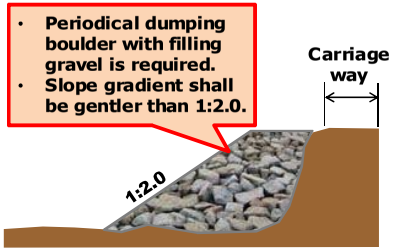
- Riverbank is eroded every year.
- Concrete Blocks were partially installed on the riverbank, but these were washed out.
- DEP 50 dumps soil on the riverbank several times a year.

10. Site Inspection Result & Applicable Measures for Riverbank Erosion

Applicable Measures for Riverbank Erosion: Bazar-Korgon-Arstanbap Road: 15.6km(DEP50)



Option-1: Spur Dike



Option-2: Riprap (Dumping Boulder/Gravel)

Thank you for your attention!

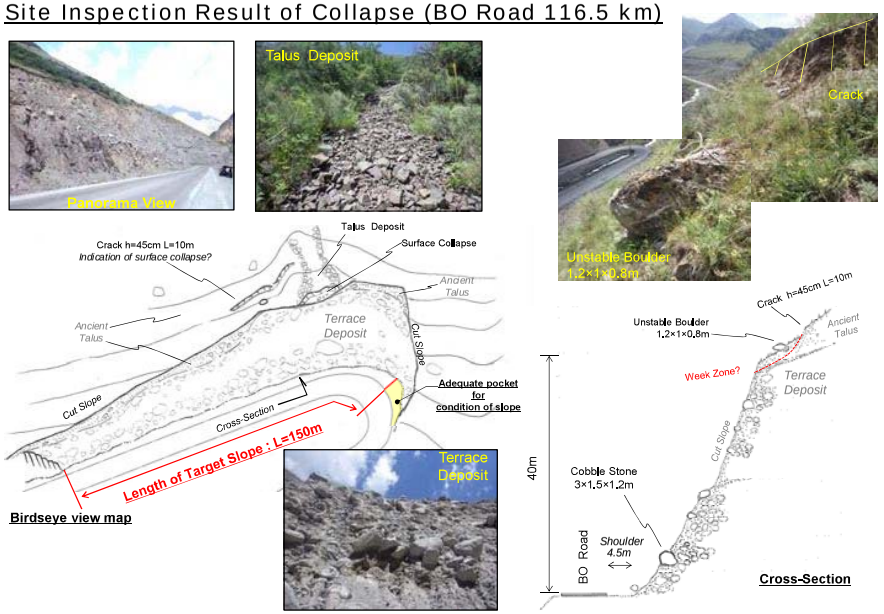
Большое спасибо!

Рахмат!

IC2-1

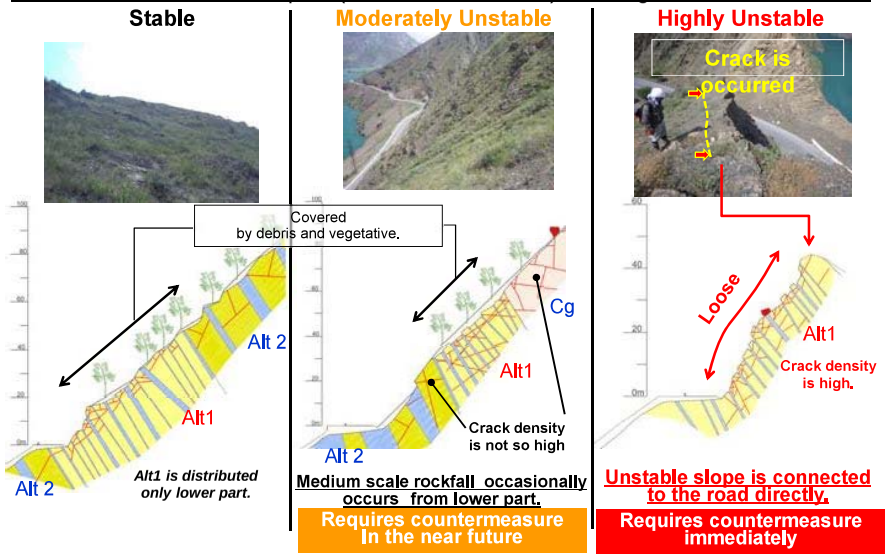
7. Site Inspection Result & Applicable Measures for

Site Inspection Result of Collapse (BO Road 116.5 km)



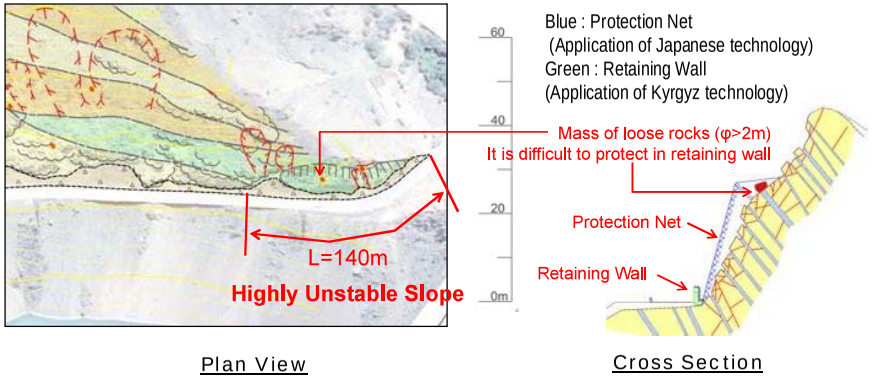
4. Result of Site Inspection for Slope Disaster

Rockfall/Bedrock Collapse (414.7 km: DEP30) Geological Cross-Section



5. Countermeasures against Slope Disaster

Countermeasures against Rockfall/Bedrock Collapse (414.7km: DEP30)

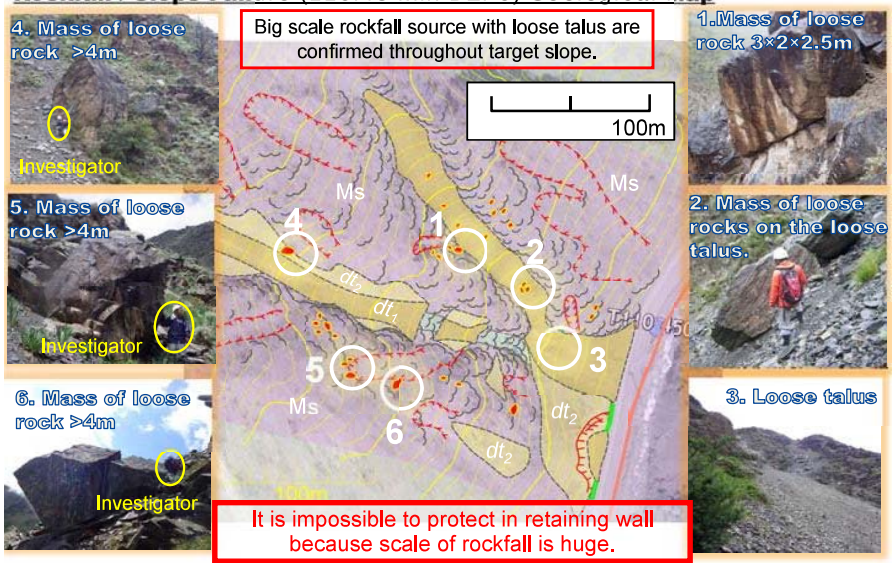


Plan View　　Cross Section

Type of Countermeasure	Execution quantity	unit	Cost / unit	Total Cost (som)
Retaining Wall H=3m	140	m	84,000	11,760,000
Protection Net H=30m	140 × 30	㎡	12,000	50,400,000

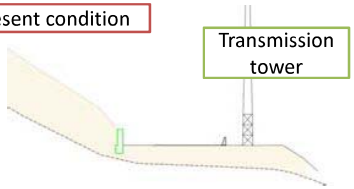
4. Result of Site Inspection for Slope Disaster

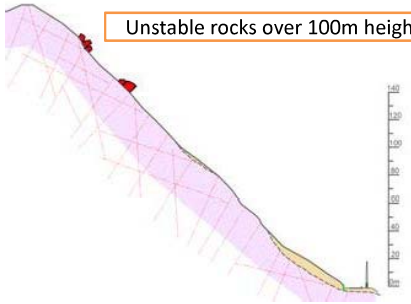
Rockfall / Slope Failure (110.45 km: DEP9) Geological Map

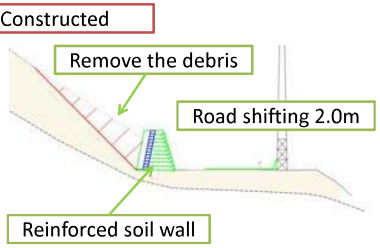


5. Countermeasures against Slope Disaster

Countermeasures against Rockfall/ Slope failure (110.45 km: DEP9)







Type of Countermeasure	Qty	unit	Cost / unit	Total Cost (som)
Reinforced soil wall H=5m	50	m	600,000	30,000,000

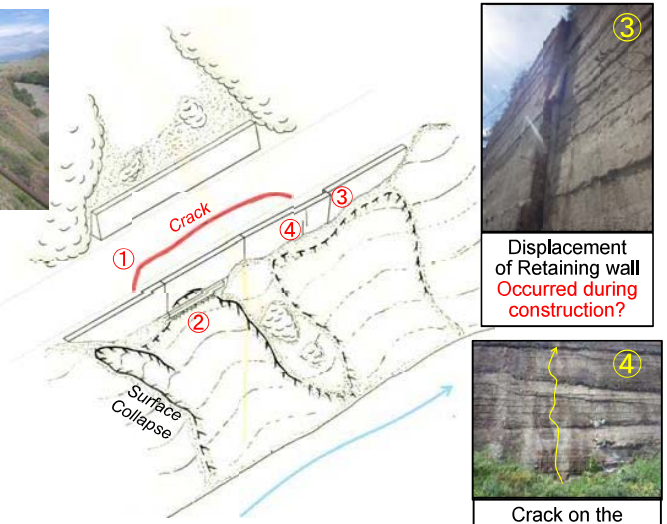
4

391.5km

398km

7. Site Inspection Result & Applicable Measures for 114.4km Bishkek-Naryn-Torugart road

Site Inspection Result of Collapse (BNT Road 114.4 km)

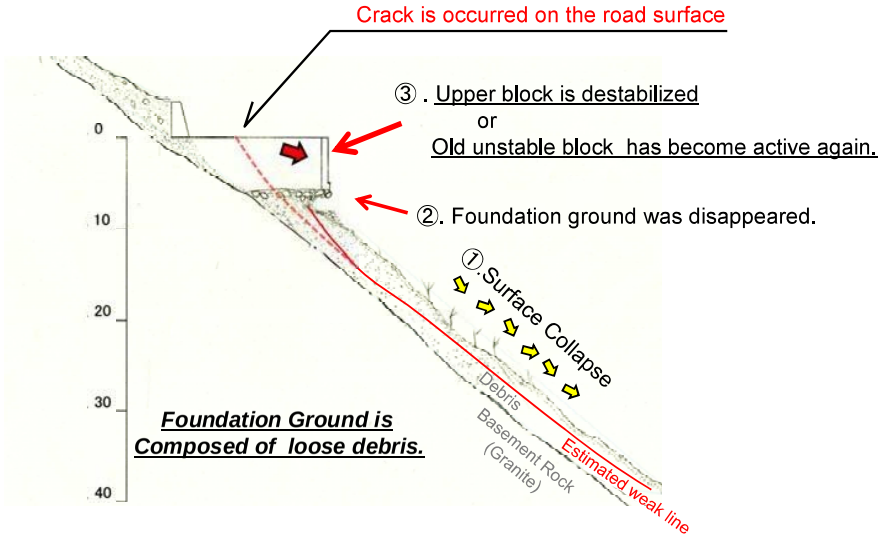


Displacement of Retaining wall Occurred during construction?

Crack on the Retaining wall

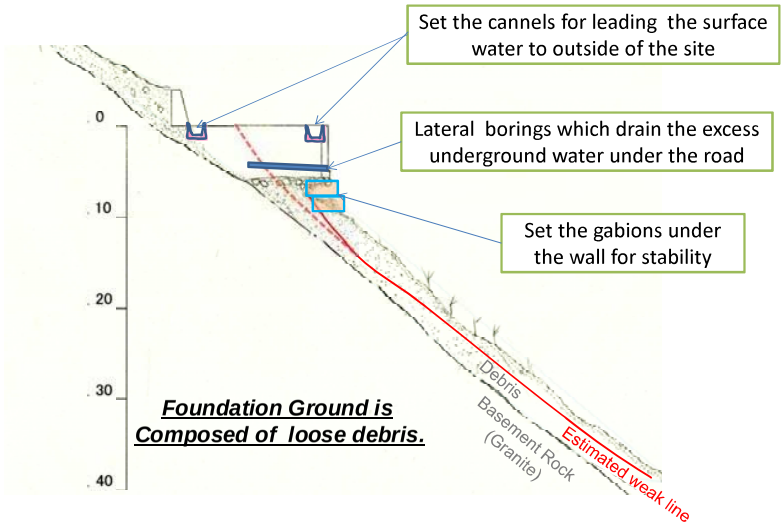
7. Site Inspection Result & Applicable Measures for 114.4km Bishkek-Naryn-Torugart road

Site Inspection Result of Collapse (BNT Road 61km: DEP959)



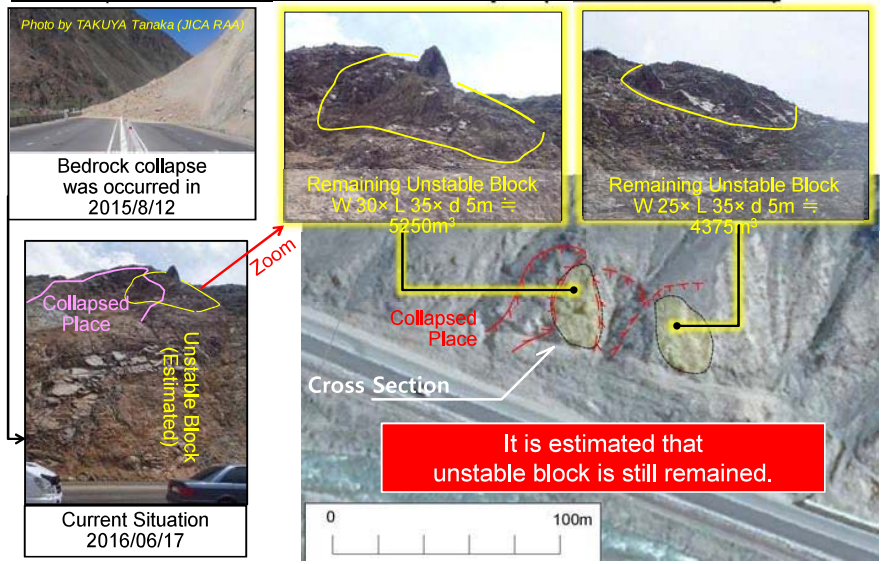
7. Site Inspection Result & Applicable Measures for 114.4km Bishkek-Naryn-Torugart road

Site Inspection Result of Collapse (BNT Road 61km: DEP959)



7. Site Inspection Result & Applicable Measures for 131km Bishkek-Naryn-Torugart road

Site Inspection Result of Bedrock Collapse (BNT Road 131 km)

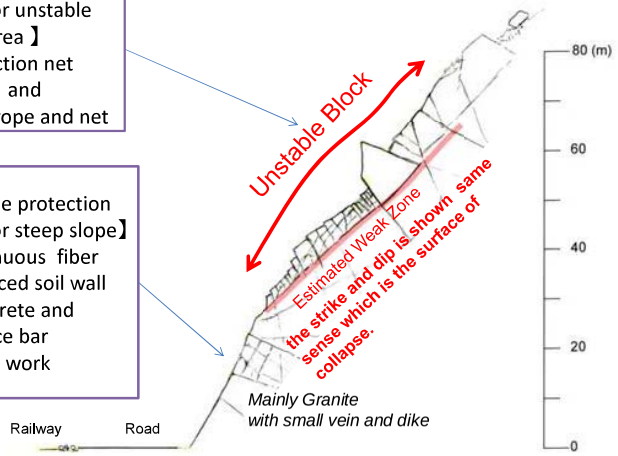


7. Site Inspection Result & Applicable Measures for 131km Bishkek-Naryn-Torugart road

Site Inspection Result of Bedrock Collapse (BNT Road 131 km)

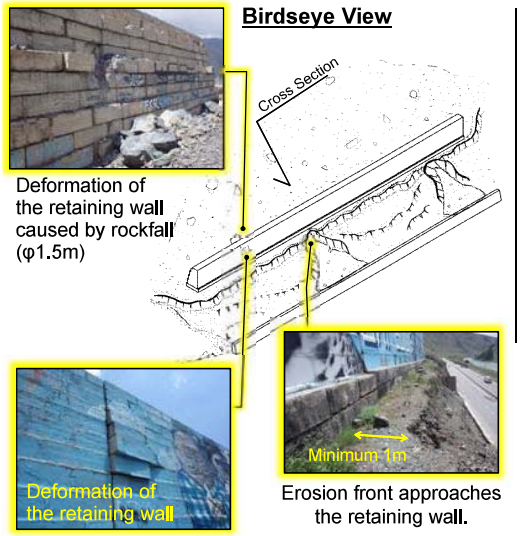
【Some protection work for unstable mass area】
・Protection net and
・Wire rope and net

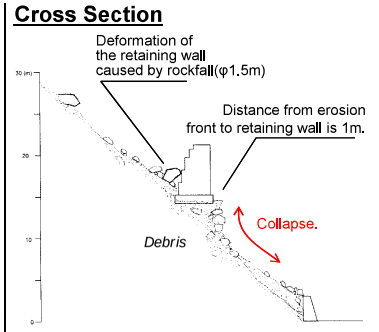
【Some protection work for steep slope】
・Continuous fiber Reinforced soil wall
・Shot crete and reinforce bar
・Frame work



7. Site Inspection Result & Applicable Measures for 132km Bishkek-Naryn-Torugart road

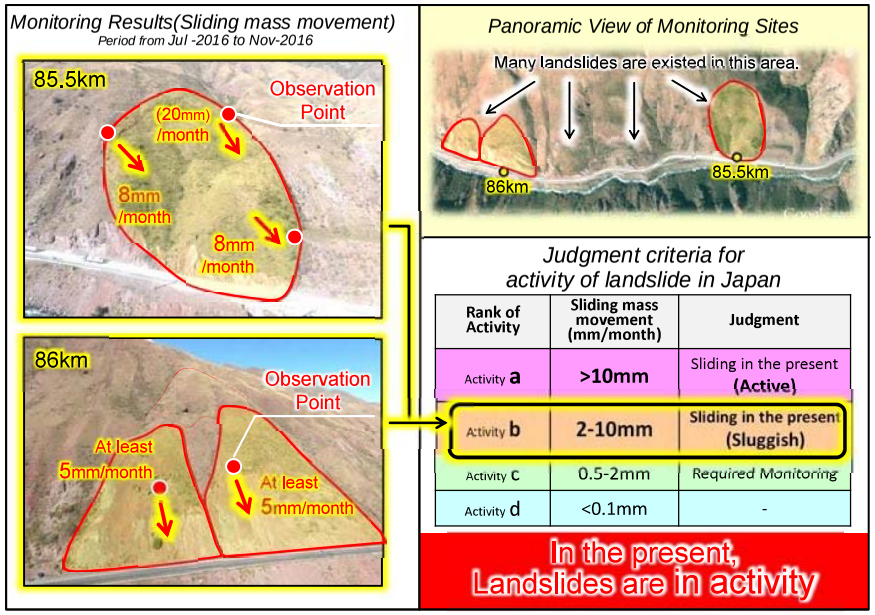
Site Inspection Result of Collapse (BNT Road 132 km)



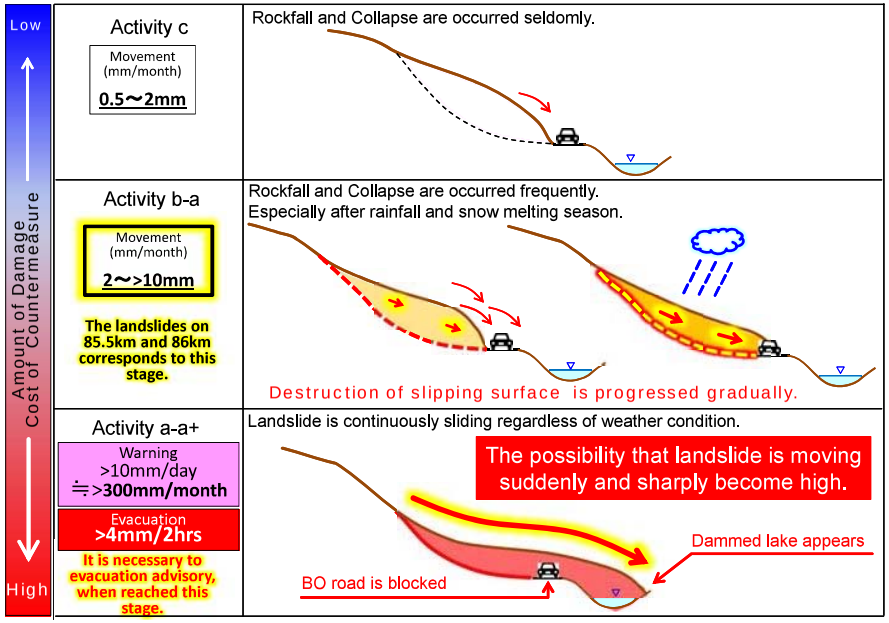


For keeping the stability of the upper retaining wall, collapse zone should be protected by some countermeasures. Also reduce the risk of the collapse to keep the safety of the road traffic.

1-1. Current Situation of Landslide on 85.5 - 86km , BO road



1-2. Current Situation of Landslide on 85.5 - 86km , BO road



2. Estimation of Disaster Scale

The following disasters are estimated, when landslide activity becomes more active.
In the near future, the countermeasures will be required.

Road Blocked on BO Road

Estimation of Disaster Scale (Maximum)

Length of Section : 1200m
Period of blocked : 1 month

Dammed lake outburst flood attacks residence area

Estimation of Disaster Scale

- Residents will be died.
- Houses will be destroyed.
- Agricultural land will be destroyed etc.

The flood simulation is necessary to estimate about details.

From above things, the monitoring must be continued.

IC3-1

The Project for Capacity Development for Road Disaster Prevention Management in the Kyrgyz Republic

Non Structural Measures

2017 10 04

IC4-1

Basic Concept :
To reduce vulnerability against hazard by road disasters

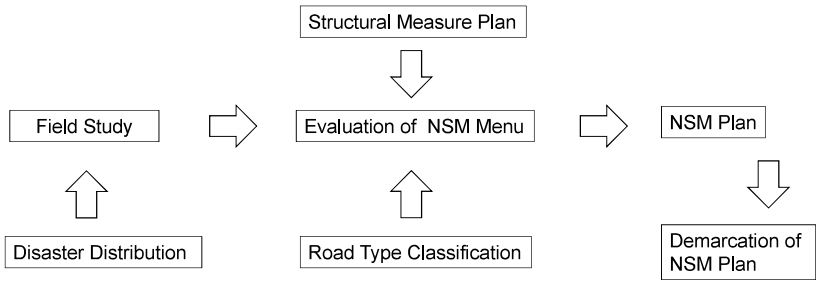
Target of Non Structural Measures(NSM)

I. Avoidance of the Direct damage to Users

II. Minimizing the Impact on Social activities

III. Reduction of Disaster by Natural phenomena

Methodology of the Study

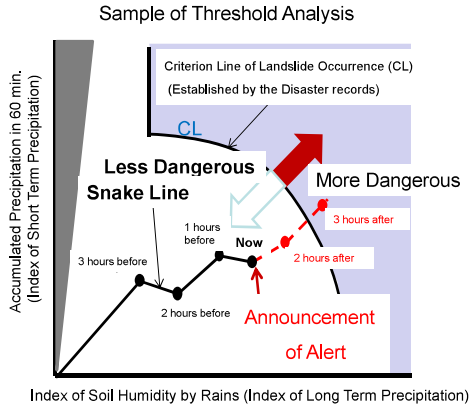


Improvement for Disaster information System

Content of Information is too general to judge the risk of road disaster by DEPs

DEPs share real time meteorological data with MES

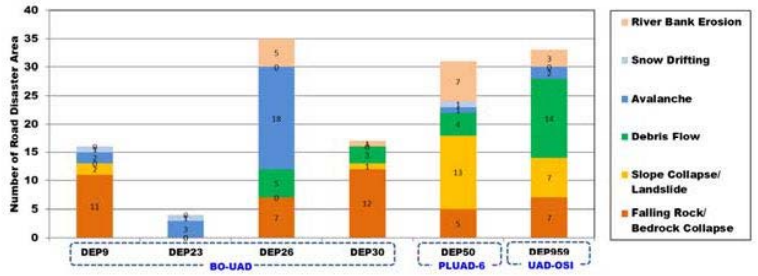
MES set monitoring station along the Road, establish threshold for road disaster



Disaster Record by DB System

(As of August 2017)

UAD	DEP	Falling Rock/ Bedrock Collapse	Slope Collapse/ Landslide	Debris Flow	Avalanche	Snow Drifting	River Bank Erosion	Total
BO-UAD	DEP9	11	2	0	2	1	0	16
	DEP23	0	0	0	3	0	0	3
	DEP26	7	0	5	18	0	5	35
	DEP30	12	1	3	0	0	0	16
PLUAD6	DEP50	5	13	4	1	1	7	31
OSI-UAD	DEP959	7	7	14	2	0	3	33
Total		42	23	26	26	2	15	134



5

Improvement for Disaster Treatment

DEP's Response for Disaster is not always perfect for the uncertainness of disaster occurrence ⇨ MoTR share real time meteorological data with MES

DEP's shortage of heavy equipment influences the road regulation period ⇨ Procurement of heavy equipment of MoTR

There are many small scale disasters which is not recorded in any organization ⇨ MoTR organize disaster record format for daily patrol and collect small scale disaster data precisely

Improvement for Signs

Some of road signs installed by prior project are broken or stolen,
There are some lack of road sign at necessary point ⇨ MoTR shall install road signs at necessary points

Dangerous area of debris flow is not clear for the drivers ⇨ MoTR shall install sign board before debris flow area

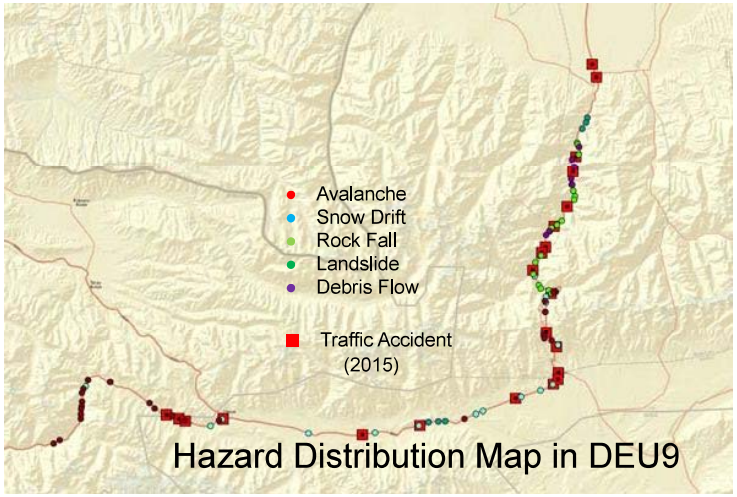
There is no way for DEP to announce disaster information directly to drivers in traffic ⇨ MoTR shall install electrical sign board

Hazard map for Road users

RMD/UAD creates
Hazard Map for Road users
Using hazard record

⇩

DEU distributes
Hazard Map to Drivers
At tool gates etc.



IC4-2

Hazard map for Road users

Utilization of Hazard map

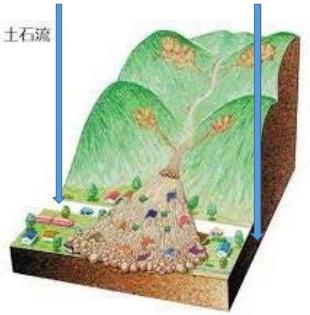
Create more friendly map for public to build up the interest for Road and Safety

Use maps for education program material to local people by UAD/RMD

Elaborate detailed road hazard map for road management

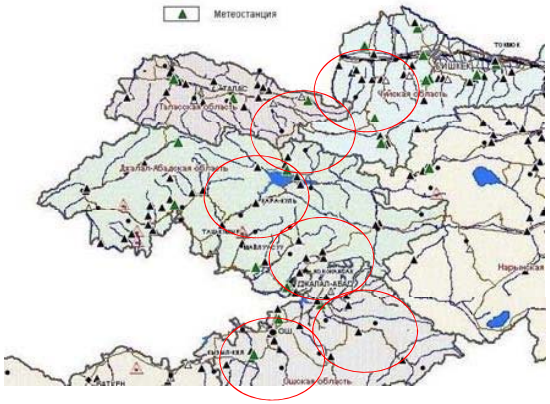
Sign Board Alert for debris flow area

Install both side of debris flow area



RMD
Fund Budget ⇨ DEP / PLUAD UAD
Select install area by urgency

Share real time meteorological data with MES



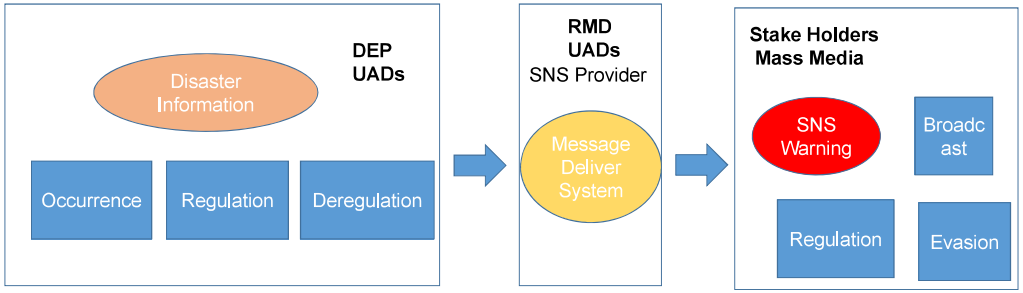
MES Monitoring Station

Real time
Meteorological data

RMD
UADs and DEPs

Preparedness for Disaster
Correlate with disaster record
Establish protocol for disaster

Outline of SNS Information System



Emergency Measure

To protect road from occurred disaster

Embankment
(counter weight for landslide)

Large sandbag wall

Inspection to Prevent
Secondary Disaster

Demarcation in MoTR

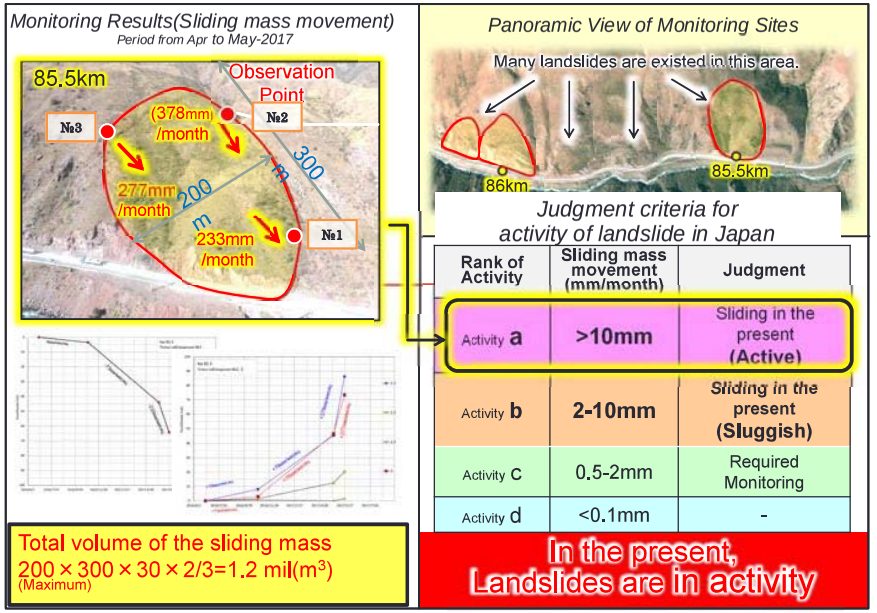
RMD/AMS
Formulating the National road disaster prevention plan (Budget, Management, DB)

UAD/PLUAD
Planning Measures with Priority
Management of Road Disaster Area
Secondary Disaster Prevention

DEUs
Patrol and Inspection with Record
Response and Recovery for Disaster

Monitoring and structural countermeasures

1-1 Current Situation of Landslide on 85.5 - 86km , BO road



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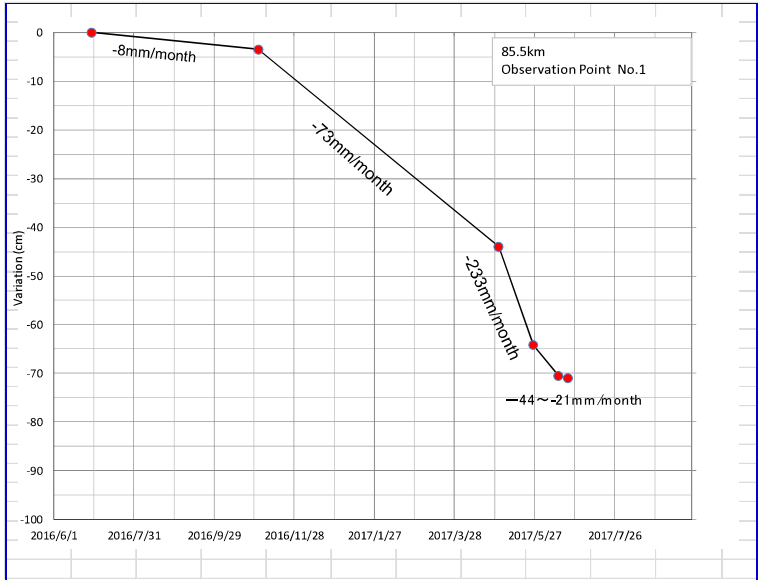

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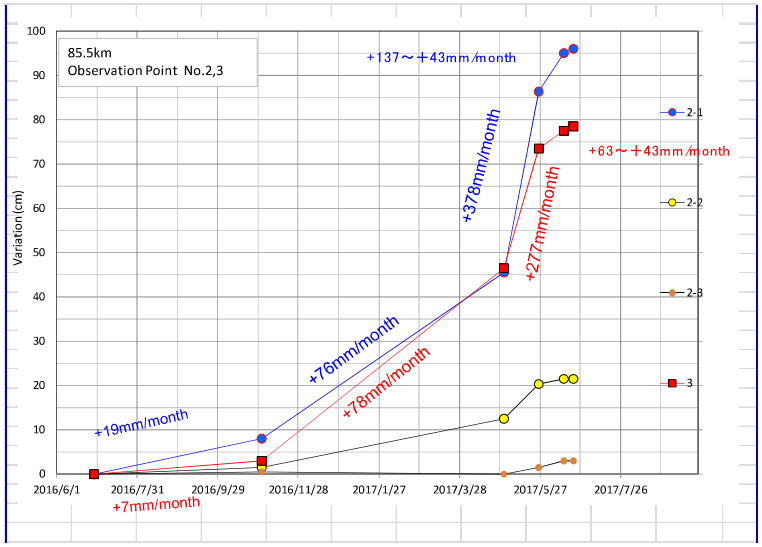


1-1 Current Situation of Landslide on 85.5 - 86km , BO road

Criteria for moving amount and speed

Landslide evaluation criteria based on the measurement results using a ground extensometer[2] with partial revision

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

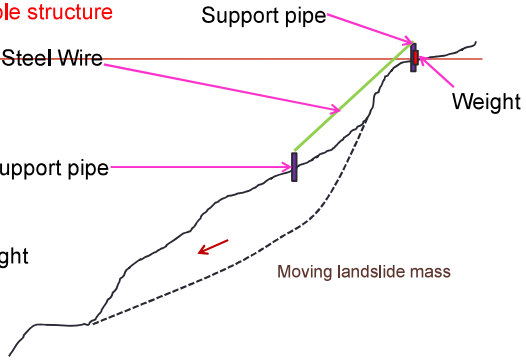
Просим Вас высказать свое мнение!! Давайте обсудим данный вопрос!

1-1 Current Situation of Landslide on 85.5 - 86km , BO road

Importance of monitoring

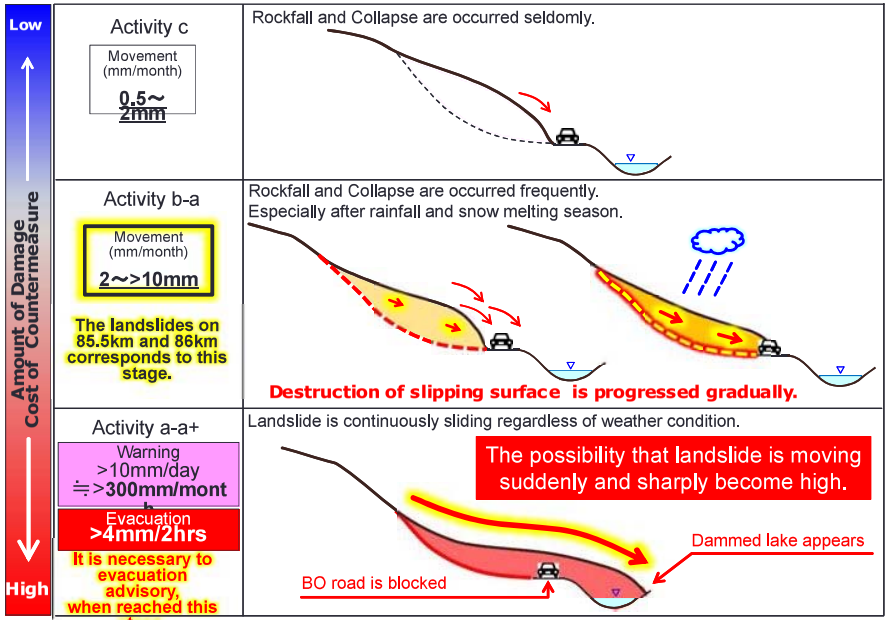
- Understand the situation at the site → Activity of the landslide is difficult to understand only by visual appearance
- Prepare for urgency → respond appropriately to changes in situations in advance
- Prevent expansion of damage → If response is delayed, the damage will expand and require a huge budget for countermeasures

Measuring instruments with simple structure



Please let us hear your opinion!! and let's diccuss!!

1-1 Current Situation of Landslide on 85.5 - 86km , BO road



1-2 Discussion about plan of new countermeasure. (85.5km:DEP9)

2. Estimation of Disaster Scale

The following disasters are estimated, when landslide activity becomes more active.
In the near future, the countermeasures will be required.

Road Blocked on BO Road

Estimation of Disaster Scale (Maximum)

Length of Section : 1200m

Period of blocked : 1 month

Dammed lake outburst flood attacks residence area

Estimation of Disaster Scale

- Residents will be died.
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- Agricultural land will be destroyed etc.

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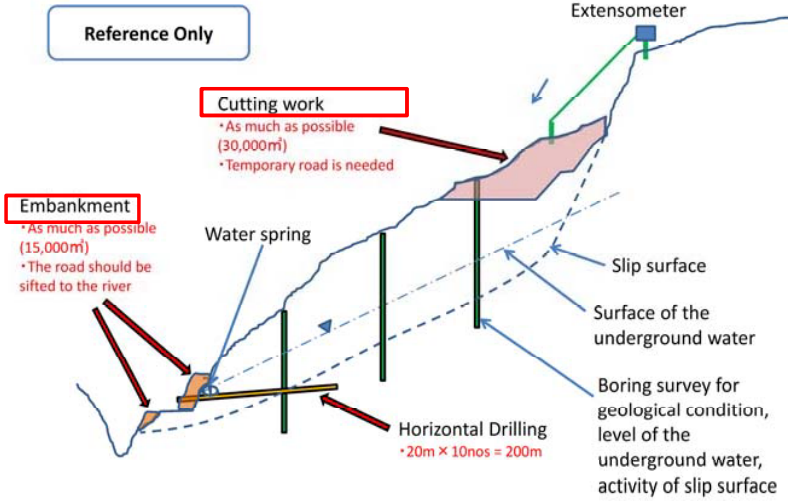
From above things, the monitoring must be continued.

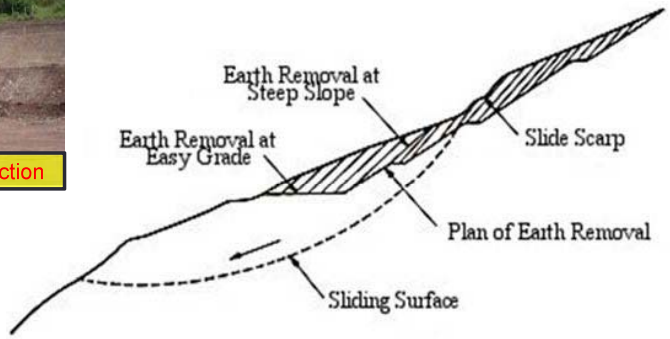
1-2 Discussion about plan of new countermeasure. (85.5km:DEP9)



1-2 Discussion about plan of new countermeasure. (85.5km:DEP9)

What kind of countermeasure work is necessary?

Example of construction



Approx V=30,000（minimum）
C = 35 (mil COM)

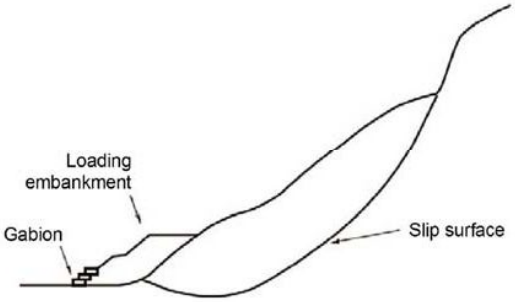
Please let us hear your opinion!! and let's diccuss!!

1-2. Discussion about plan of new countermeasure. (85.5km:DEP9)

What kind of countermeasure work is necessary?

Approx V=15,000（minimum）
C = 20 (mil COM)

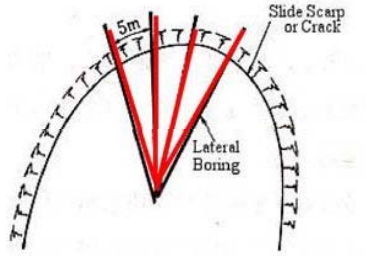
Example of construction

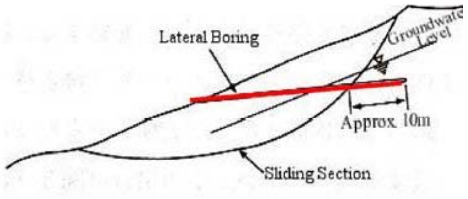


Please let us hear your opinion!! and let's diccuss!!

1-2. Discussion about plan of new countermeasure. (85.5km:DEP9)

What kind of countermeasure work is necessary?





Example of construction

Approx L=200（minimum）
C = 5.0 (mil COM)

Example of construction

Please let us hear your opinion!! and let's diccuss!!

1-2 Discussion about plan of new countermeasure (85.5km:DEP9)

How to keep stability for slope of Landslode

① Horizontal drilling ② Earth Cutting work ③ Embankment

Please let us hear your opinion!! and let's diccuss!!

2. Discussion about plan of new countermeasure. (DEP9;Retaining Wall)

Existing retaining walls at BO-road DEP9

93км

94км

96км

No function due to the rock fall and debris deposit
Necessity for improvement of risk and maintenance work

Please let us hear your opinion!! and let's diccuss!!

2. Обсуждение планируемых мер по предотвращению бедствий (ДЭУ-9 Подпорная стена)

Existing retaining walls at BO-road DEP9

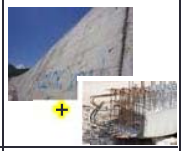
113км 2017/10/01

Please let us hear your opinion!! and let's diccuss!!

2. Discussion about plan of new countermeasure. (DEP9;Retaining Wall)

• Comparison of Retaining wall capacity

The Example for Capacity of Retaining Walls

	Repairing Existing retaining wall	Gabion Retaining wall with waste tire	Concrete Retaining wall	Reinforced Concrete Retaining wall
Type of Countermeasure				
Capacity of Shock absorbing	Very Low (almost not)	Low-Middle	Middle	High *but It is not enough*
Cost of Countermeasure*1)	What's the estimated price for this?	82,500 com / m?? ≒12 M com / 140m	120,000 com / m ≒17 M com / 140m	>17 M com / 140m
Easiness of the repairing Work	Moderate?	Easy	Difficult	More difficult
Remarks	The retaining wall will be broken again in the near future.	Although it is expected that retaining wall will be broken easily, the repair work is inexpensive and easy.	Probably, The introduction of concrete retaining wall is easy. Because It is already installed in OSI road.	The possibility that the retaining wall breaks cannot be denied. In that case, the cost for repair work is expensive.

*1) Estimated by unit price of specialist works in Japan

The slopes which has the same situation exists much in DEU9.
Please let us hear your opinion!! and let's diccuss!!

2. Discussion about plan of new countermeasure. (DEP9;Retaining Wall)

How to keep stability for slope of Rock fall

Gabion wall against rockfall
(Other country)

Please let us hear your opinion!! and let's diccuss!!

3. Discussion about plan of new countermeasure.(DEP30 ; 414.7km)

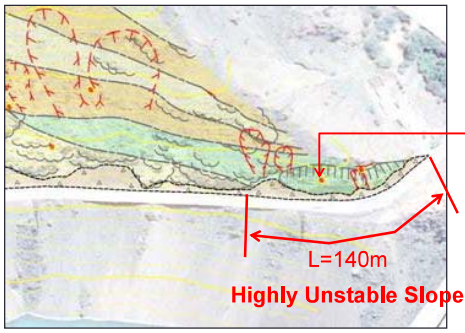
How to keep stability for slope of Rock fall

Site situation of 414.7km BO road

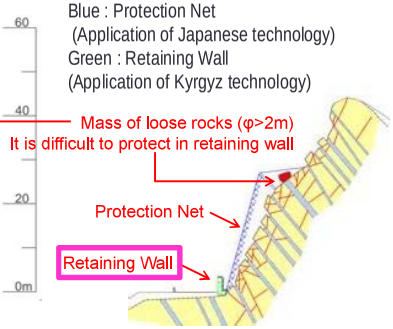
Please let us hear your opinion!! and let's diccuss!!

3. Discussion about plan of new countermeasure.(DEP30 ; 414.7km)

Countermeasures against Rockfall/Bedrock Collapse (414.7km: DEP30)



Plan View



Cross Section

Please let us hear your opinion!! and let's diccuss!!

3. Discussion about plan of new countermeasure.(DEP30 ; 414.7km)

How to keep stability for slope of Rockfall

The Russian presentation material from TOKYO ROPE MFG.CO.,LTD

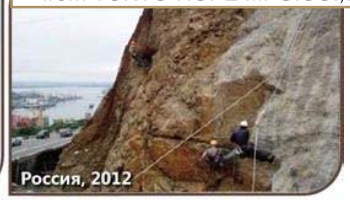
Protection net ; One of countermeasure work for rock fall

Please let us hear your opinion!! and let's diccuss!!

3. Discussion about plan of new countermeasure.(DEP30 ; 414.7km)

How to keep stability for slope of Rockfall

The Russian presentation material from TOKYO ROPE MFG.CO.,LTD



Protection net ; One of countermeasure work for rock fall

Please let us hear your opinion!! and let's diccuss!!

IC6-1

INTRODUCTION

■History of 85.5km Landslide

2009-2010: After road widening project, landslide movement occurred.

2014 July: JICA study team identified the slope as 6th priority.
(but, it was not listed in the short list of Yen loan project)

2016 June: On-site monitoring has started under cooperation of JICA TCP .

2017 June: Landslide movement was accelerated over 26cm/month.
3 extension meters were installed by MOTC under JICA TCP.

2017 October: Drone survey was conducted to clarify landslide mechanism and to estimate necessary countermeasures.

PUPOSE OF DRONE SURVEY

■Issues and Objects

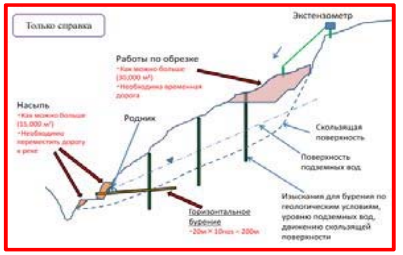
- Slope evaluation have been conducted by on-site inspection mainly from roadway.
  → Landslide mechanism and its extent are not cleared.
- Detailed topographic map is not available.
  → Landslide stability analysis cannot be done for estimation of countermeasures.

■Purpose 1: To Clarify Overall Picture

- To clarify topographical condition
- To presume cause of landslide
- To evaluate possible extent of landslide

■Purpose 2: To Provide Terrain Data

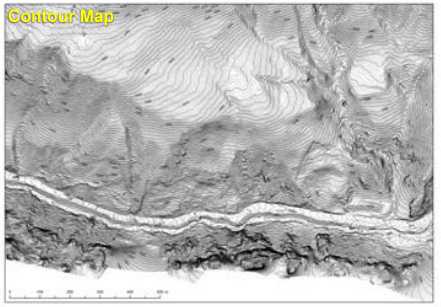
- To prepare terrain data for slope stability analysis
- To conduct slope stability analysis using available information

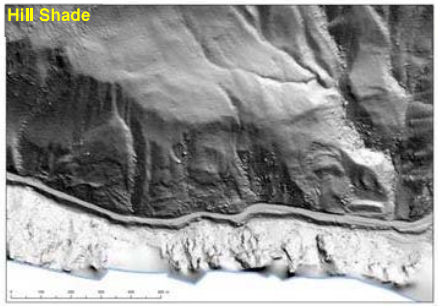


Schematic Proposed Countermeasure

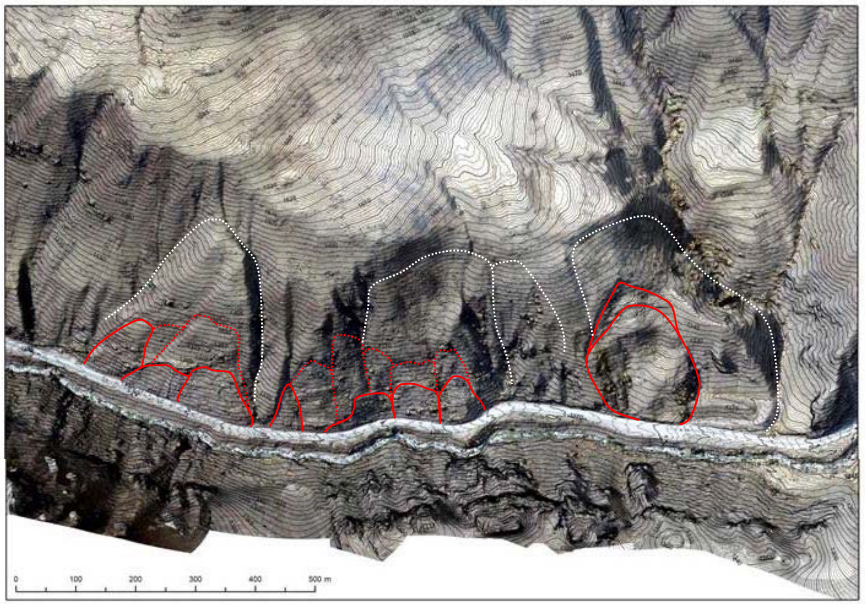
RESULT OF DRONE SURVEY

RESULT OF DRONE SURVEY





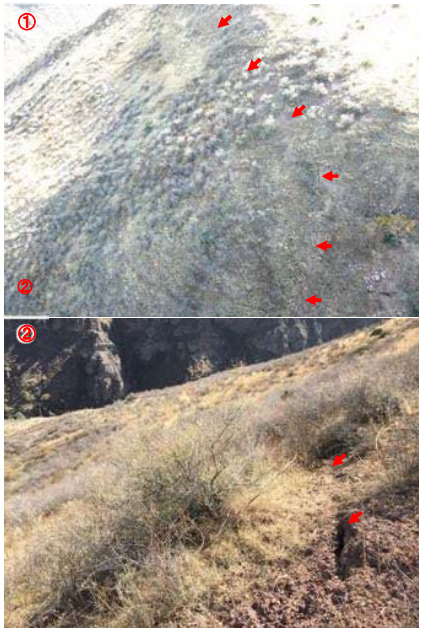
OVERALL PICTURE at 85.3km~86.6km

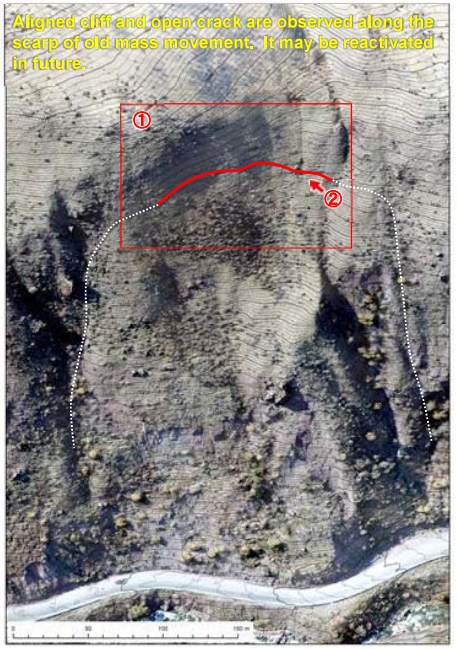


OVERALL PICTURE at 85.3km~86.6km

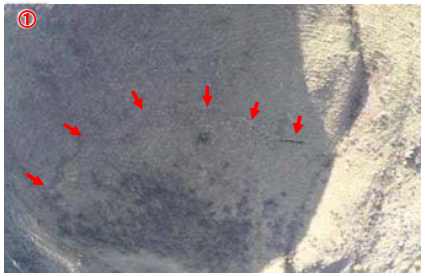
- In previous time, huge mass-movements occurred at margin of gentle terrace plain according to river erosion. Those have been stable for long time.
- Due to road construction and widening (cutting slopes), the end of slopes became unstable. Slope failure continuously occurred.
- At 85.5km, unloading of slope foot caused deep-seated landslide.

Surface Deformation at 85.5 km

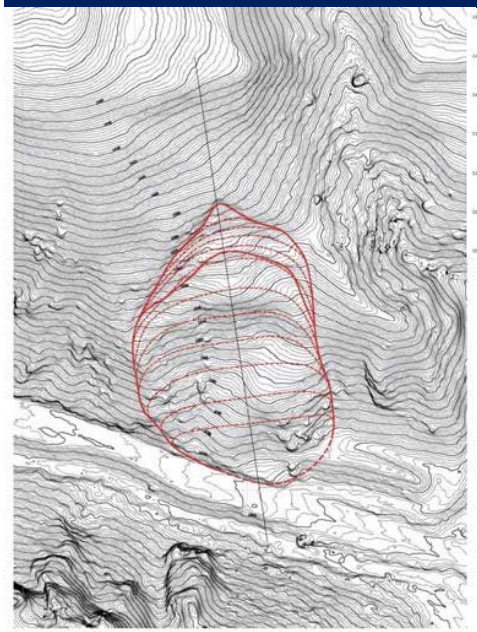


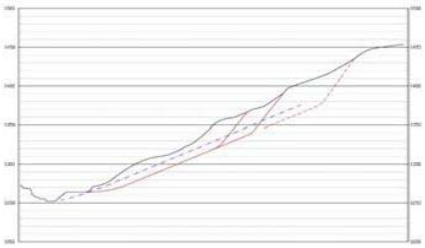


Surface Deformation at 85.9 km



SLOPE STABILITY ANALYSIS



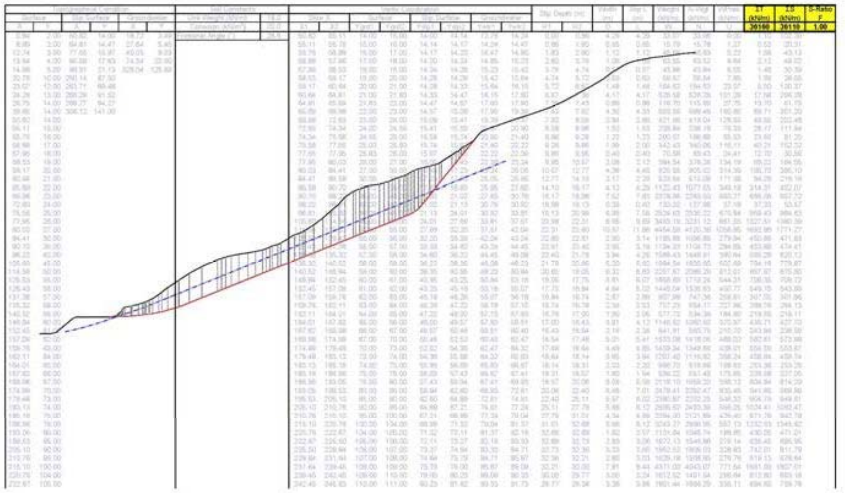


■Analysis Condition

- Slip depth is estimated 1/7-1/10 of landslide width (=18-25m).
- Slip plain is presumed parallel to the ground surface.
- Landslide toe is located at roadway elevation.
- Groundwater level is estimated about 10m above of the slip plain (constant), considering springs along the road.

All information should be verified based on additional inspection.

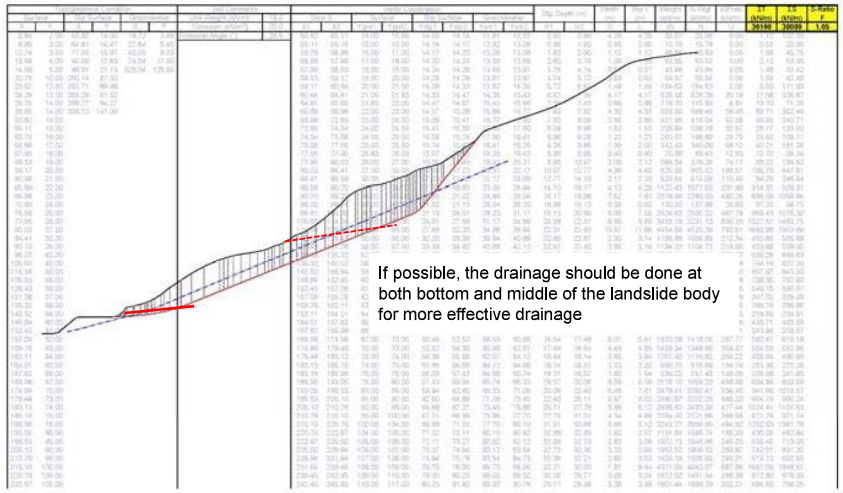
SLOPE STABILITY ANALYSIS



■Current Condition (FS = 1.00)

- Cohesion "c" is estimated 20 kN/m^2, based on slip depth (18~25m).
- When c = 20kN/m^2, Internal Friction Angle "φ" is 26.6 degree.

SLOPE STABILITY ANALYSIS

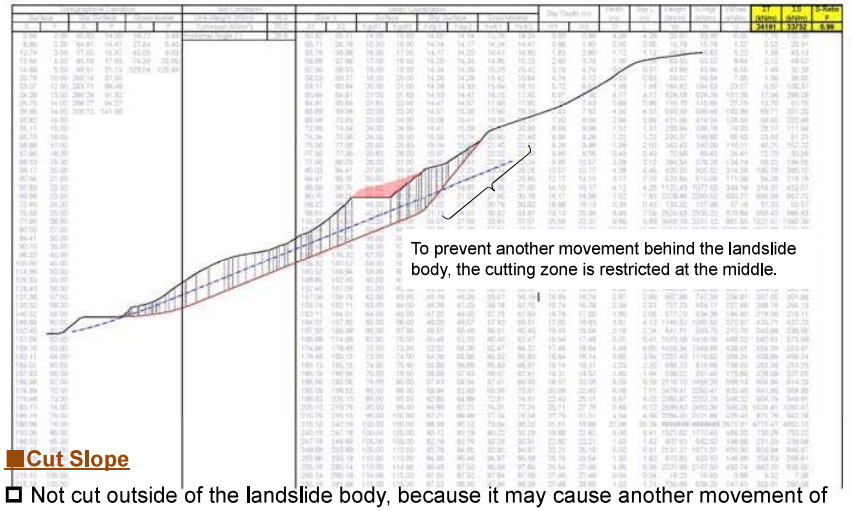


■Drainage by Horizontal Bores

- Horizontal bores from road level. 3m groundwater lowering is estimated.

⇒ FS = 1.05

SLOPE STABILITY ANALYSIS

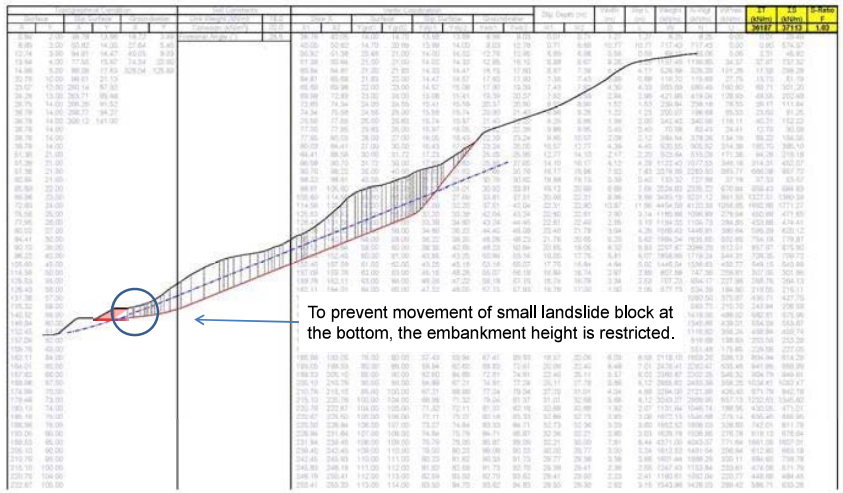


■Cut Slope

- Not cut outside of the landslide body, because it may cause another movement of upper mass
- Cut angle is 1:1.0. Cut slope height = 20m

⇒ FS = 0.99

SLOPE STABILITY ANALYSIS



■Embankment Loading

- Embankment angle is 1:1.8. Embankment height = 7m

⇒ **FS = 1.03**

COUNTERMEASURES

■Drainage by Horizontal Bores

- Drainage seems most effective countermeasures. If possible, the drainage should be done on the middle terrace of the landslide body in addition to the bottom.

■Cut Slope

- Cut slope is effective countermeasures when it is applied at the top of landslide body. However, because there is another movement is suspected behind the landslide body, the cutting zone is restricted only at the middle.
- Therefore, it is not effective countermeasures.

■Embankment Loading

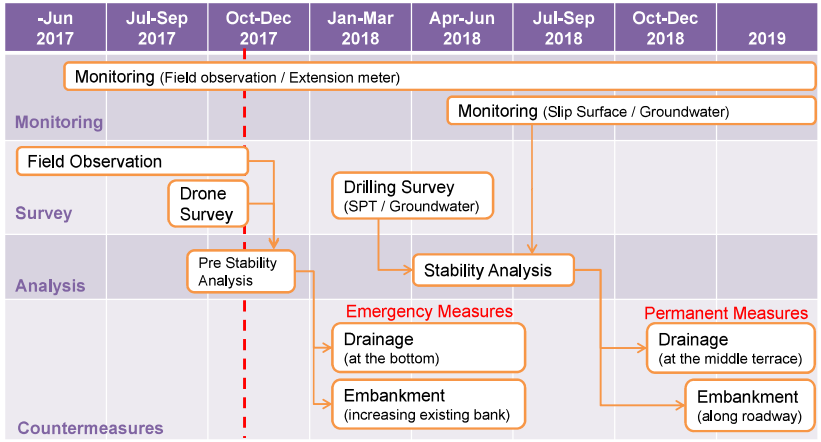
- Embankment is also effective. However, to prevent movement of small landslide block at the bottom, the embankment height is restricted.
- There is an artificial embankment at the side. To increase the counterweight of the embankment is also effective.

Countermeasures	FS	Remarks
Drainage by Horizontal Bores	1.05	L = xx m x 15 lot
Cut Slope	0.99	Cut height = 20m, Angle 1:1.0
Embankment Loading	1.03	Embankment height = 7m, Angle 1:1.8

COUNTERMEASURES

■Proposed Schedule

- Countermeasures shall be implemented in 2 phases
  1) Emergency drainage and embankment based on existing information
  2) Permanent drainage and embankment based on drilling survey result.
- Based on verification of 2 drainages' effect, permanent embankment shall be done.



CONCLUSION

■Landslide Character and Its Extend

- Slope failures and deep-seated landslides at the end of slopes may trigger re-activation of mass movement blocks behind.
- At the slopes 85.7km~86.6km, active movement area is still limited at the end of slopes at the moment. However it may be extended upward in future.
- At the slope 85.5km, active movement area is already shifted to the middle of slope. A huge deep-seated landslide was formed. Estimated road block duration by the landslide movement is longer (over 1 month). ⇒ **Higher Priority**
- In both slopes, quantitative monitoring not only at the end but also at the scarps of old mass movement is highly required.

■Applicability of Drone Survey

- Regular patrol is basically conducted from the roadway. Detailed inspection is difficult because appropriate terrain map is unavailable.
- Drone survey provides detailed terrain information in wide area, which is essential for planning and designing of effective countermeasures.
- Drone survey can detect tiny surface deformation. It can be utilized for long duration landslide monitoring.

The Project for Capacity Development for Road Disaster Prevention Management in the Kyrgyz Republic

Slope Disaster Prevention Work
2018 04

Basic Concept of training course:

Determine the type of slope disaster and consider the basic plan of countermeasure work include the cost for budget.

1. Types of slope disasters

Rockfall and landslide are representative disasters in Kyrgyzstan. Social influence is so large and occurrences has been reported so many cases.

・Difference of slope disaster

Type	Rockfall	Landslide	Slope collapse
Moving speed	Very fast	Slow	Fast
Average of the Scale	Very Small to middle (φ=0.5～10m)	Small to Very large (L=10～1000m)	Small to large (W=3～100m)
Sign of moving	Difficult to find	Usually appear	Sometimes appear
Monitoring	Difficult to apply	Usually using	Sometimes using
Main water Influence	Rainfall	Ground water	Rainfall and Groundwater
Main Prevention works	・Cutting(Removal work) ・Ground Anchor ・Protection net ・Protection fence ・Earth dyke	・Earth work ・Drainage work ・Ground anchor ・Steel pile ・Shaft work	・Grating crib work ・Rock bolt ・Ground anchor ・Shot creet

1. Types of slope disaster

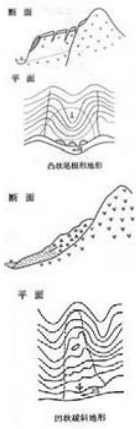
【Rockfall】

BO Road Dep30

BO Road DEP9

1. Types of slope disaster

【Landslide】

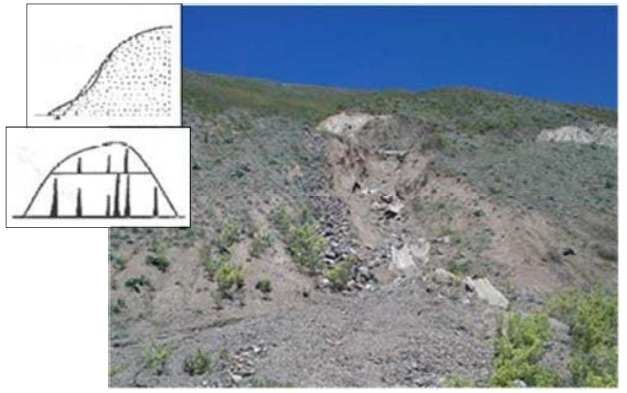


BO Road Dep9 (85.5km)

DEP959

1. Types of slope disaster

【Slope collpse (Slope failure)】



BO Road Dep30

BNT Road

IC7-2

Target of the slope disaster prevention work

I. Prevent the slope disasters from occurring

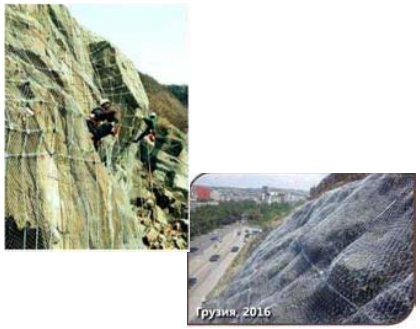
II. Avoidance of the recurrence of slope disaster

III. Minimizing the Impact of slope disaster

2. Disaster prevention work

【Rock Fall】Prevention Work (1/2)

Concrete foot protection (BO Road Dep23)



Wire rope and net (Japan / Georgia)

2. Disaster prevention work

【Rock Fall】Prevention Work (2/2)

Shotcrete (Japan)

Frame work and rock bolt (Japan)

2. Disaster prevention work

【Rock Fall】Protection Work (1/2)

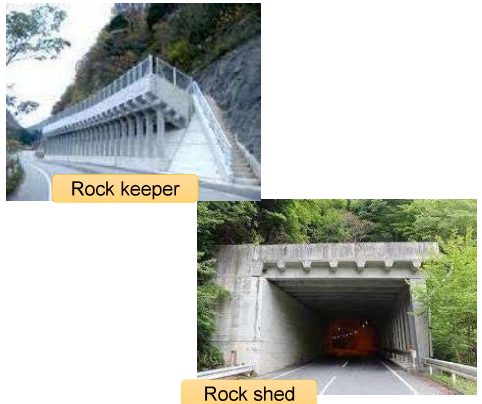
Protection Fence (Japan)

Pocket type protection net (Japan)

2. Disaster prevention work

【Rock Fall】Protection Work (1/2)

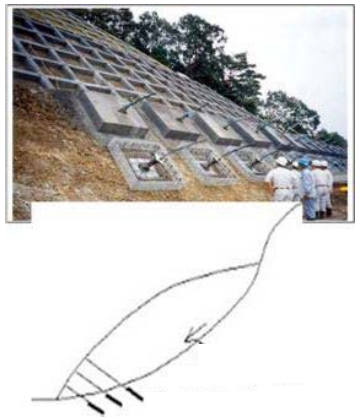
Retaining wall (Bolivia, Japan)



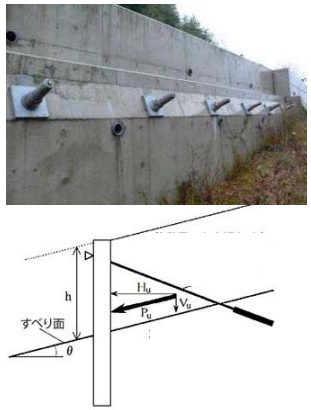
Structure of concrete (Japan)

2. Disaster prevention work

【Landslide】Prevention works (1/2)



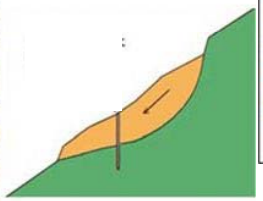
Ground Anchor work



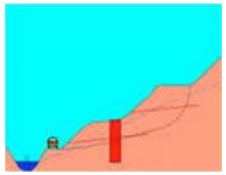
Pile with anchor work

2. Disaster prevention work

【Landslide】Prevention works (2/2)



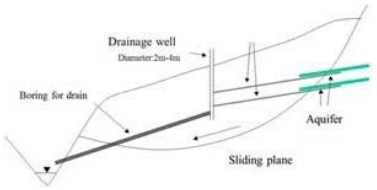
Steel Pile work



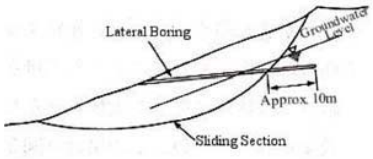
Shaft work

2. Disaster prevention work

【Landslide】Control works (1/2)



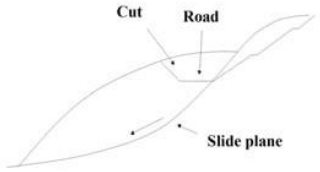
Catchment well



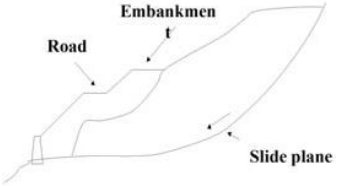
Horizontal boring

2. Disaster prevention work

【Landslide】Control works (2/2)



Earth removal work (Cutting)



Counter weight (Embankment)

Determination of prevention work

【Rock fall】

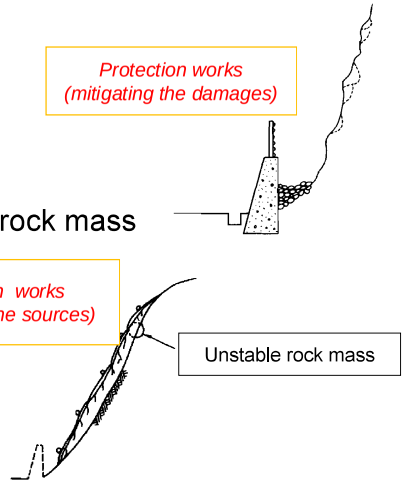
Points

Scale of the disaster

1) Scale of the unstable rock mass

2) Area and Distribution of the unstable rock mass

- Workability
- Land use and extra space along the road



Determination of prevention work

【Landslide】

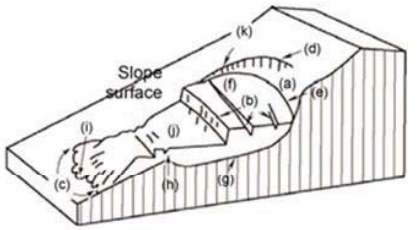
Points

Character of the landslide

1) Scale of landslide (width , length, depth)

2) Direction of the moving

3) Step of the activity



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

Fig. Appendix 4 Names of typical positions in a landslide [6) w

Determination of prevention work

【Landslide】

Sufficient survey and analysis is necessary for consideration of landslide countermeasures

- Field survey
- Analysis of the topography
- Geological survey (Boring and various testing)
- Monitoring of deformation of land surface, slip surface, groundwater level, activity of the ground water
- Various geophysical exploration
- Analysis of landslide mechanism

Structural measures and Non-structural measures

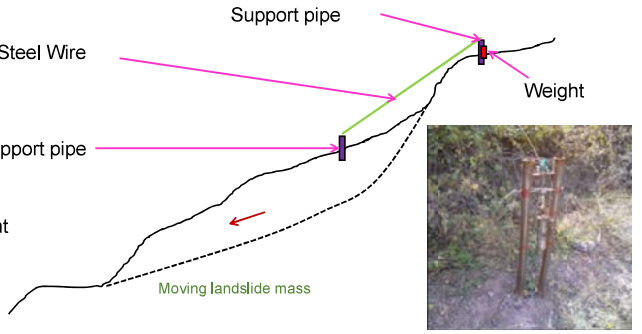
Types	Merit	Demerit
Structural measures	➢ Directly measures ➢ Reliable effect to the site	➢ Requires investigation and design ➢ Need times for implementation ➢ Costs the construction fee ➢ Sometimes needs big budget
Non-structural measures	➢ Indirect measures	➢ Costs not so much ➢ Start the work rapidly ➢ Target the many sites at the same time

3. Nonstructural Measures (Landslide monitoring)

Importance of monitoring

- Understand the situation at the site → Activity of the landslide is difficult to understand only by visual appearance
- Prepare for urgency → respond appropriately to changes in situations in advance
- Prevent expansion of damage → If response is delayed, the damage will expand and require a huge budget for countermeasures

Measuring instruments with simple structure



BO-road 85.5km

3. Nonstructural Measures (Landslide monitoring)

Оборудование	Материал	Характеристики	Количество
Трос	металл	L:20m, Ø 2mm	1
Роллер	металл	Ø10-15cm	1
Труба (ПВХ)	ПВХ	L :1m, Ø 15cm	1
Якорь	металл, пластик	L:20cm, Ø 10cm	1
Колья	металл, пластик	L:1-1.5m, Ø 5cm	2

BO-road 85.5km

3. Nonstructural Measures (Landslide monitoring)

Criteria for moving amount and speed

Таблица Критерии для принятия решений в случае оползня в Японии

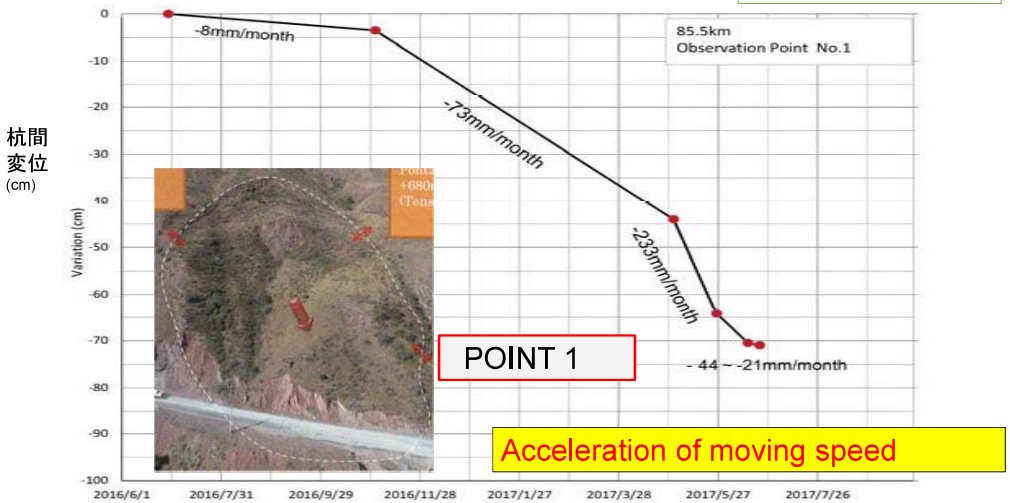
Тип изменений	Изменение за сутки (мм)	Совокупная величина изменения (mm)	Совокупная тенденция к определенному направлению	Общеая оценка	
				Оценка оползня	Уровень активности
Тип А	Менее 1	Более 10	Значительный	Четко выраженная	Интенсивная активность, скольжение в поверхностных и глубоких слоях
Тип В	0.1～1	2～10	Менее значительный	Почти четко выраженная	Движется медленно, глинистые отложения осыпаются
Тип С	0.02～0.1	0.5～2	Незначительный	В скрытом состоянии	Необходимо постоянное наблюдение
Тип Г	Более 0.1	нет	Нет	Отклонение от нормы	Локальная деформация грунтов

Источник：Принципы технологии профилактики оползней и комментарии

IC7-6

Monitoring Result of BO road 85.5km POINT 1

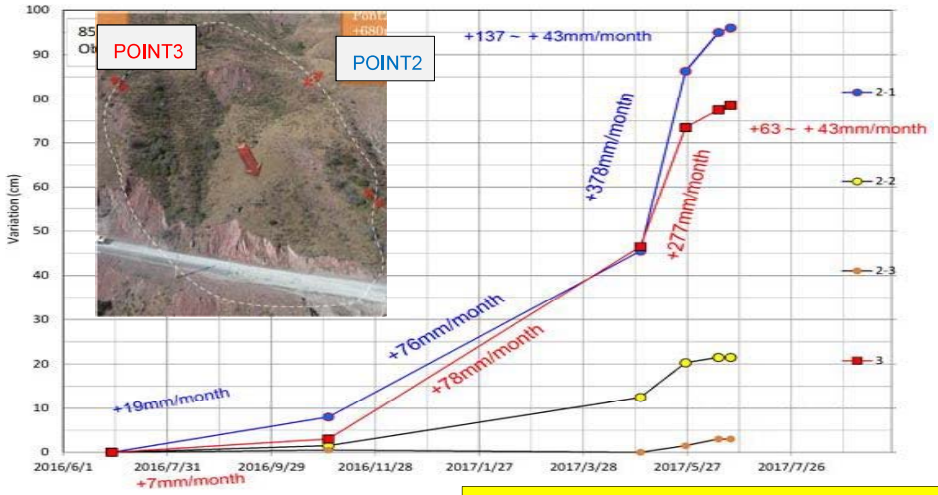
BO-road 85.5km



Acceleration of moving speed

Monitoring Result of BO road 85.5km POINT 2 and 3

BO-road 85.5km

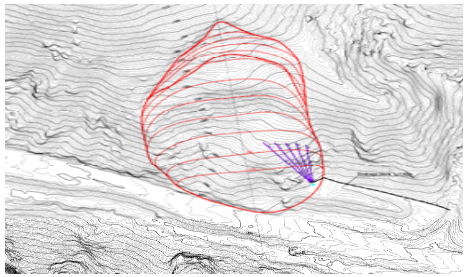


Acceleration of moving speed

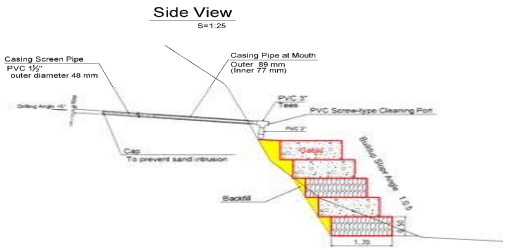
Drainage Drilling at 85.5km on BO Road

Countermeasure Plan and Schedule

Plan



Details



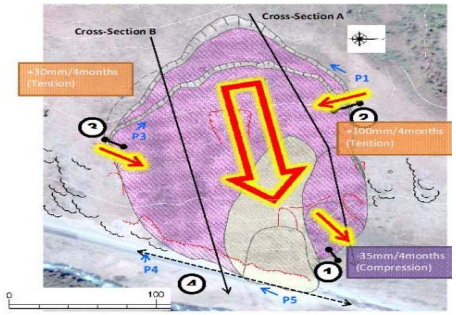
Time Schedule

2018.3	2018.4	2018.6	2018.7	2018.8	2018.9
Planning	Preparation Bidding Document	Bidding	Construction		Monitoring

Drainage Drilling at 85.5km on BO Road

Outline

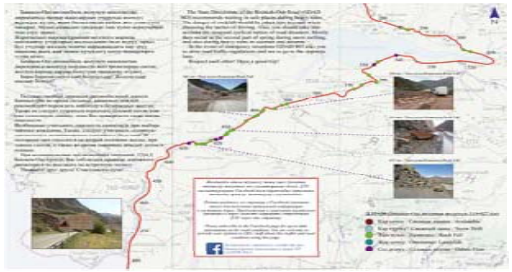
- Counter measure plan for landslide at 85.5km on BO road was drafted by MOTR and Project Team.
- On this site, the skill and knowledge regarding to the inspection, monitoring and countermeasure planning was transferred as one of good study case.



Hazard Map Distribution Plan

Outline

- Under the cooperation of MOTR and JICA project team, a map of hazardous areas along the Bishkek-Osh road (Hazard Map) was prepared on January 2018.
- The number of copies to be printed is about 169 500 copies (for DEUs 9 & 23: 127 000 copies, for DEU 30: 42 500 copies) with financial assistance of UNDP.



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4.Estimation for Approximate construction cost for Budgeting

Disaster type	Work 1	Work2	Work3	Nonstructural Measures
Classification for the work	Post disaster work	Disaster prevention work	Disaster prevention work	Disaster prevention work
Landslide	Removal work after sediment discharge coming to the road	Horizontal drainage drilling (16,000 KGS/m)	Large scale Earth works Ground anchor work Steel piles Drainage wells (30-120Mil-KGS/site)	Monitoring work for displacement (0.1Mil-KGS/site-year)
Rockfall	Removal work after Rock mass reaching to the road	Protection net (13,000 KGS/m2) Gabion wall (90,000 KGS/m)	High energy type Net and Fence Reinforced soil wall (30-120Mil-KGS/site)	Hazard map Distribution (0.18 Mil-KGS)
Remarks	Routine Maintenance work	Keep Budgets by annual planning	Project for donner or some international institution	

5.Cases of Japanese technological counter measure work

- Main works : Horizontal drainage drilling
- Site : The Republic of Sri Lanka
- Construction duration : 2016 – 2017
- Quantity : 50.0 m × 10 nos = 500.0 m
- Construction cost : 3,600,000KGS = 7,200KGS/m (only for the horizontal drilling)
- Contractor : Domestic construction company


5.Cases of Japanese technological counter measure work

- Main works : Catchment Wells
- Site : The Republic of Honduras
- Construction duration : 2012– 2014
- Quantity : 12 wells for 2 landslide sites
- Construction cost : approximately 630 Mil KGS
- Contractor : Japanese construction company


5.Cases of Japanese technological counter measure work

- Main works : Earth works, Drainage tunnel, Ground anchor, Shaft work
- Site : Nagano prefecture in Japan
- Construction duration : 1986 - 1991
- Construction cost : approximately 9,500 Mil KGS
- Contractor : Japanese construction company


Test

1) Describe the difference of rock fall and landslide
   - Character of each disaster
   - Scale
   - Moving speed
   - Possibility of monitoring
   - Factor of moving

2) Explain for one of risk site of your administrating area and select the suitable countermeasure work or survey plan and monitoring instruments.(include the construction cost)

Thank you for your attention!

Большое спасибо!

Рахмат!