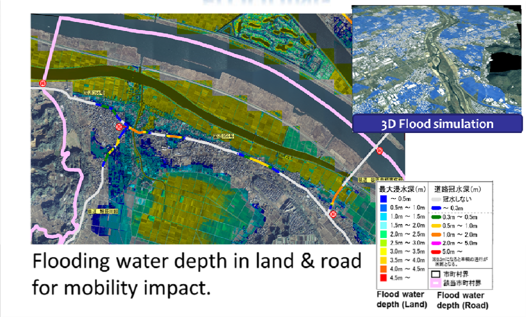
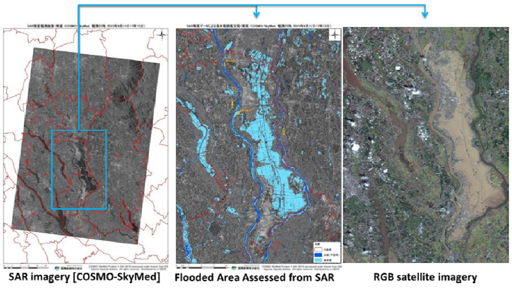
Overview of Disaster Risk Management Solutions
Countermeasure technology to different perils

Disaster Risk Management Solutions (DRM) at Kokusai Kogyo

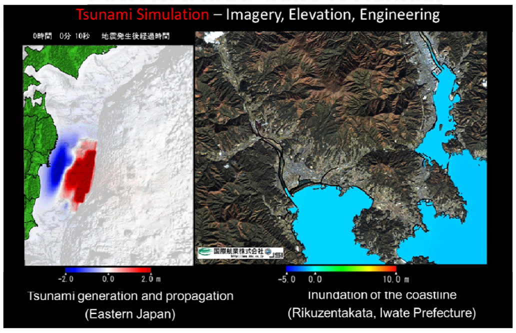
FLOODING

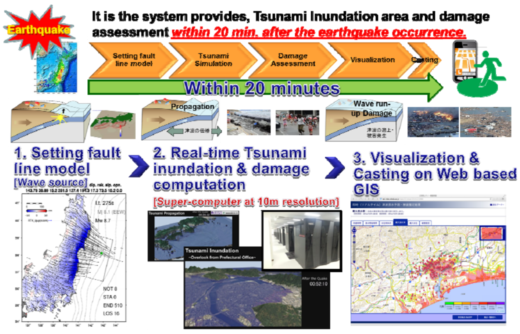


DRR: Flooded area assessment
September 2015 – Typhoon #18 Flooding [Executed as part of rapid response]



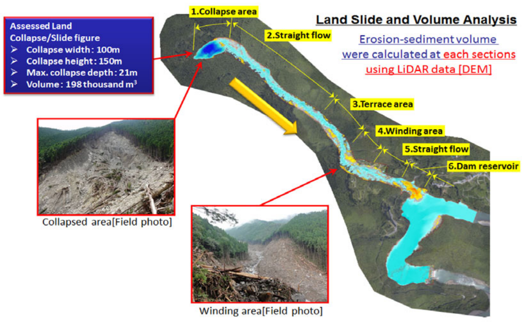
EARTHQUAKE AND TSUNAMI



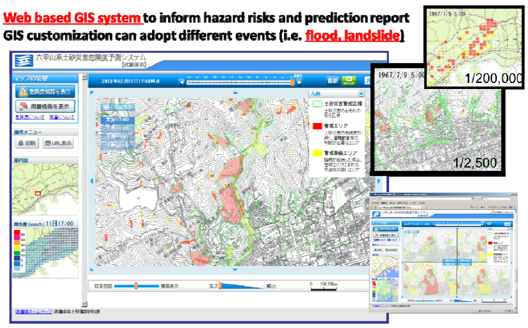


Geospatial

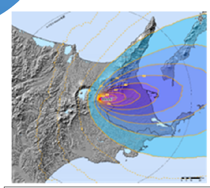
LANDSLIDE

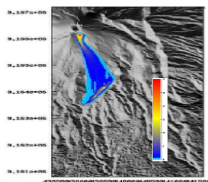


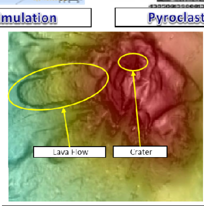
Web based GIS system to inform hazard risks and prediction report
GIS customization can adopt different events (i.e. flood, landslide)



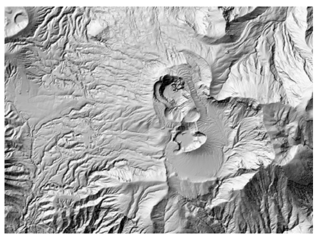
VOLCANO

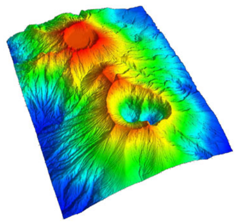

Ash Falling Simulation


Pyroclastic Simulation

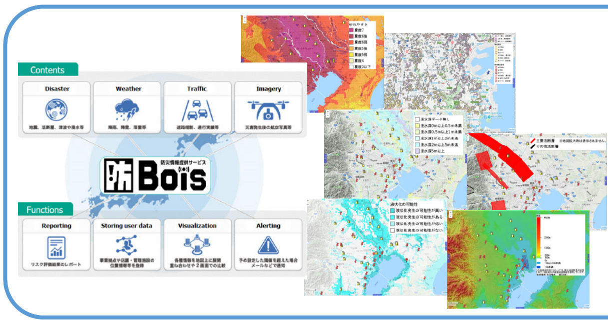


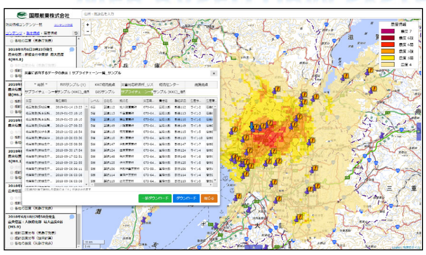
DEM Analysis (ELSAMAP)



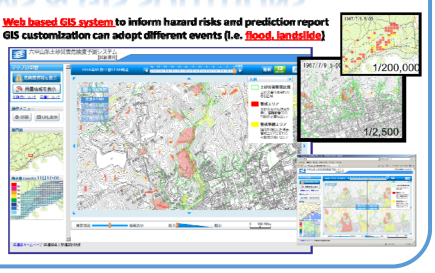


WEB BASED DRM SYSTEMS & GIS SOLUTIONS





Web based GIS system to inform hazard risks and prediction report
GIS customization can adopt different events (i.e. flood, landslide)



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JICA Technical Cooperation Project

Project for Control and Mitigation of Slope Disasters in the Central District in Republic of Honduras

Project Background

In **Tegucigalpa, Honduras,** landslides and slope failures caused by urban development have increasingly occurred during the rainy season, leading to serious damage to urban life. Since **'Slope Disaster Risk Reduction'** is an urgent task for the Central District of Tegucigalpa, the Law of the National Risk Management System (SINAGER) was formulated in 2010. SINAGER urges the entirety of the public and private sectors — in industry, academia, and government — to take concrete actions for the prevention and mitigation of disasters risks.

Given this background, the **Japan International Cooperation Agency** has decided to implement the "Project for Control and Mitigation of Slope Disasters in the Central District in Republic of Honduras".

1st Joint Coordination Committee

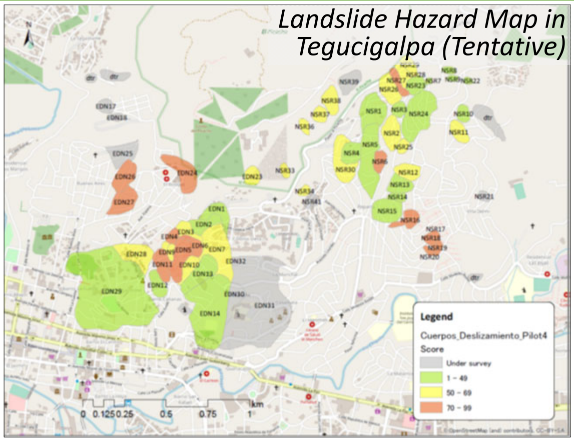
Project Overview

[Purpose]
Capacity to manage slope disasters in the Central District is improved.

[Counterpart Agencies]
The Municipal Hall of the Central District (AMDC), the Permanent Contingency Commission of Honduras (COPECO), and the National University Autonomous of Honduras (UNAH).

[Project Period]
February 2019 to March 2022

[Target Area]
Central District of Tegucigalpa, Honduras.

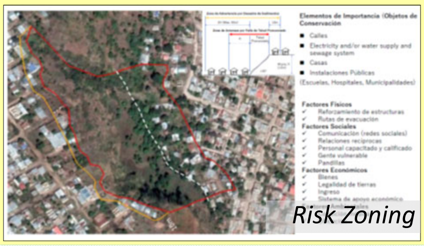


Landslide Hazard Map in Tegucigalpa (Tentative)

Project Outputs

Output 1: Capacity building on detailed investigation and analysis to identify slope disaster phenomena

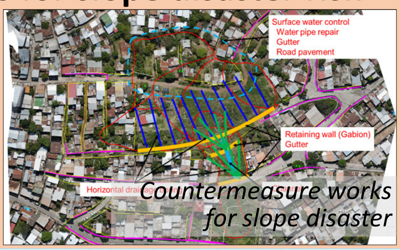
Electrical resistivity logging



Risk Zoning

Output 2: Capacity building on design, construction, management, and maintenance of structural measures for slope disaster risk

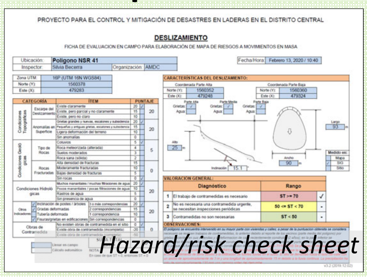
Countermeasure works for slope disaster



Countermeasure works for slope disaster

Output 3: Capacity building on the preparation of hazard and risk maps for slope disaster

Seminar on hazard/risk check sheet



Hazard/risk check sheet

Output 4: Capacity building on land use regulation for slope disasters

Discussion of regulation content

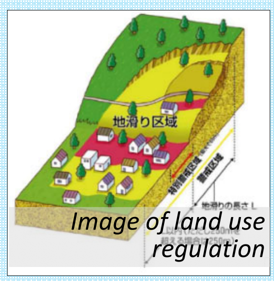


Image of land use regulation

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JICA Technical Cooperation Project

Utilization of Japanese Technology for Slope Disaster Prevention:

THE PROJECT FOR CAPACITY DEVELOPMENT ON COUNTERMEASURES OF SLOPE DISASTER ON ROADS IN BHUTAN

Bhutan is located at the foot of the Himalayas, with 95% of its land mountainous. It has carried out slope disaster prevention inspections along national roads with the support of the Japan International Cooperation Agency (JICA) and, based on the results, the Bhutan Department of Roads (DoR) has formulated the Road Disaster Prevention Management Master Plan.

Currently, JICA is conducting a technical cooperation project in which the DoR is implementing road slope countermeasures in accordance with the Road Disaster Prevention Management Master Plan. Many Japanese technologies for slope disaster prevention are being used in this project.

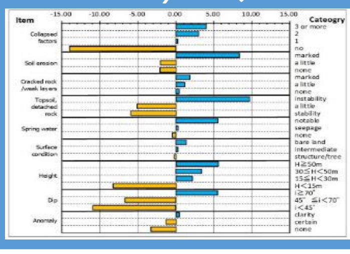
Inspection for Road Slope Disaster Prevention

◆Japanese technology for and knowledge on road slope disaster prevention inspection

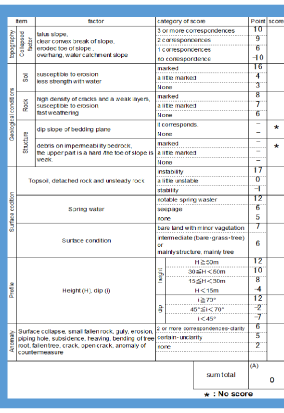
◆Quantitative hazard evaluation method for slope disasters on roads using multivariate statistical analysis

◆Preparation of risk assessment sheet exclusively for Bhutan

Score setting by multivariate statistical analysis ↓



Risk assessment sheet for Bhutan →



Item		factor	category of score		Point	score
topography	Collapsed factor	talus slope, clear convex break of slope, eroded toe of slope, overhang, water catchment slope	3 or more correspondences		10	
			2 correspondences		9	
			1 correspondences		6	
			no correspondence		-10	
Geological conditions	Soil	susceptible to erosion less strength with water	marked		16	
			a little marked		4	
			None		3	
	Rock	high density of cracks and a weak layers, susceptible to erosion, fast weathering	marked		8	
			a little marked		7	
			None		6	
	Structure	dip slope of bedding plane	It corresponds.		–	*
			None		–	
		debris on impermeability bedrock, the upper part is a hard /the toe of slope is weak.	marked		–	*
			a little marked		–	
			None		–	
Surface codition	Topsoil, detached rock and unsteady rock		instability		17	
			a little unstable		0	
			stability		-1	
	Spring water		notable spring waster		12	
			seepage		6	
			none		5	
	Surface condition		bare land with minor vagetation		7	
			intermediate (bare·grass·tree) or mainlystructure, mainly tree		6	
Profile	Height (H), dip (i)		height	H≧50m	12	
				30≦H<50m	10	
				15≦H<30m	8	
				H<15m	-4	
			dip	i≧70°	12	
				45°≦i<70°	-2	
				i<45°	-7	
Anomaly	Surface collapse, small fallen rock, guly, erosion, piping hole, subsidence, heaving, bending of tree root, fallen tree, crack, open crack, anomaly of countermeasure		2 or more correspondences·clarity		6	
			certain·unclarity		5	
			none		2	
			sum total		(A)	0

★ : No score

Countermeasure Work for Road Slopes

◆Japanese technology for slope countermeasures

◆Improving the safety and work efficiency of road maintenance and management

◆Environmental protection through bioengineering works

Debris flow countermeasure work

Technology transfer

Bioengineering work

Slope countermeasure work

Monitoring and Ex-ante Traffic Control

◆Uses Japanese monitoring technology and products

◆Real-time monitoring of rainfall and slope movement

◆Web- and smartphone-based alerts

◆Construction of a system for ex-ante traffic control during heavy rainfall

On-site rain gauge and surface inclination sensor

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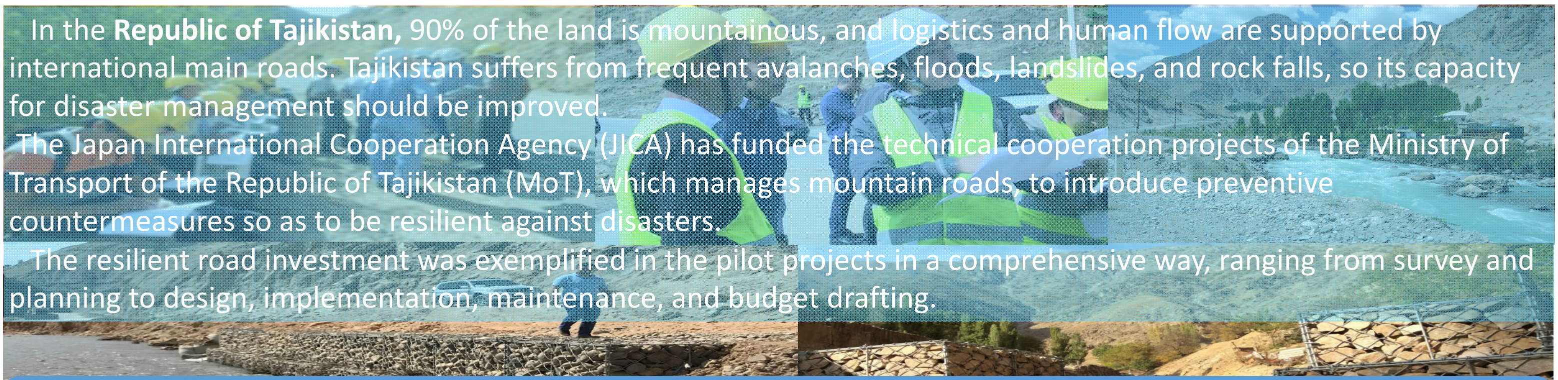
JICA Technical Cooperation Project

Introduction of Resilient Preventive Countermeasures: The Project for Capacity Development for Road Disaster Management in the Republic of Tajikistan



In the **Republic of Tajikistan,** 90% of the land is mountainous, and logistics and human flow are supported by international main roads. Tajikistan suffers from frequent avalanches, floods, landslides, and rock falls, so its capacity for disaster management should be improved.

The Japan International Cooperation Agency (JICA) has funded the technical cooperation projects of the Ministry of Transport of the Republic of Tajikistan (MoT), which manages mountain roads, to introduce preventive countermeasures so as to be resilient against disasters.

The resilient road investment was exemplified in the pilot projects in a comprehensive way, ranging from survey and planning to design, implementation, maintenance, and budget drafting.

One-stop (from survey to implementation)

◆Technology and knowledge of road disaster prevention conducted in Japan

◆Quantitative hazard evaluation method for slope disasters on roads using multivariate statistical analysis (Prioritization)

◆Design adapted according to each disaster mode (Feedback from the survey)

◆Economic implementation (Cost management)

Planning and Design

Hazard Evaluation

Implementation of countermeasures

New Concept (Preventive Countermeasures)

◆Introduction of Japanese products (Quality infrastructure)

◆Performance design based on disaster force

◆Selecting works and arrangements based on disaster modes

Prevention countermeasures against floods in the protection of roads →

Budget and Evaluation

◆Investment in infrastructure under budget constraints

◆Accountability for securing budget

◆Quantitative evaluation: Cost-to-benefit analysis

◆Index the road transport economy (3 benefits:

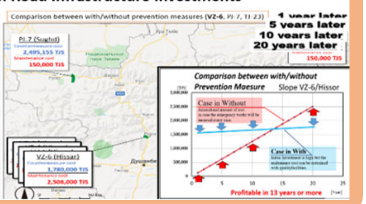
Reduction of time, travelling cost, and accidents)

Introduction of significance of road disaster management and training of road economics evaluation →

3) Pilot Study in Benefit to Cost Analysis in Road Infrastructure Investments

Basic Unit Cost of Each Vehicle

Vehicle	Total Cost of Purchase	Service Life	Rough Total Mileage
	[TJS] = 9.6 [USD]	[Years]	[km]
	240,000	5	100,000
	163,000	3	140,000
	140,000	3	80,000
	432,000	5	10,000
	672,000	5	60,000



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JICA Technical Cooperation Project

Project for Capacity Development of Disaster Management in Pakistan (CADIM)

Project Background

Pakistan has a high frequency of natural disasters, such as floods, earthquakes, and slope disasters. The Japan International Cooperation Agency (JICA) has supported the National Disaster Management Authority (NDMA) in developing the National Disaster Management Plan. However, the capacity development of organizations in disaster risk reduction (DRR) was still necessary due to the two following reasons.

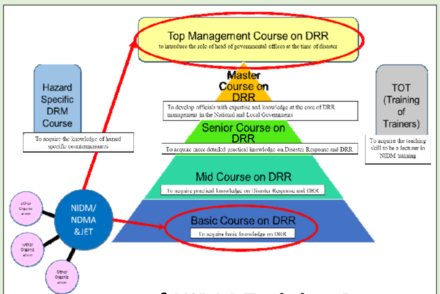
1. The organizations were new and not able to implement the National Disaster Management Plan properly; and
2. The National Institute of Disaster Management (NIDM), responsible for DRR-related training in Pakistan, was not able to provide sufficient training content.

In this situation, JICA decided to implement the Project for Capacity Development of Disaster Management.

Overview of the Project
Project Purpose To strengthen the system for human resource development in disaster management through NIDM.
Counterpart Agencies NDMA and NIDM
Project Period Mar. 2019 to Dec. 2021
Project Area Islamabad, Pakistan

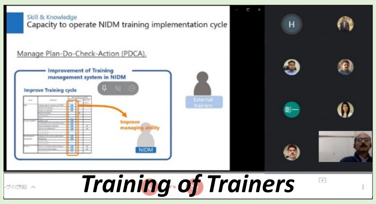
TRAINING PROGRAM

- **Development of a training program framework**, consisting of six courses, and **implementation of the Top Management/Basic Course**, which is one of these six courses. *(See the image "Concept of NIDM Training Program")*
- **Establishment of appropriate training cycle** (plan, implementation, evaluation, and improvement. *See the image "Training Cycle"*)
- **Implementation of Training of Trainers** in order to improve trainers' capacity (presentation skills, facilitation skills, and specialized knowledge. *See the image "Training of Trainers"*)
- **Establishment of Training Manuals** (basic idea on disaster risk management, early warnings and countermeasures for slope disaster and floods, etc. *See the image "Training Manuals on Disaster Trigger (Slope Disaster)"*)

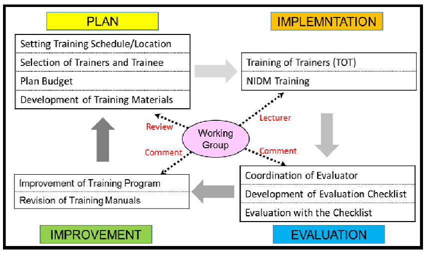


Concept of NIDM Training Program

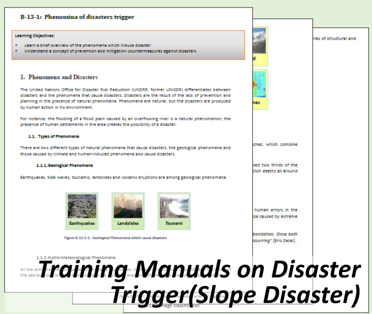
Basic Course on DRR training



Training of Trainers



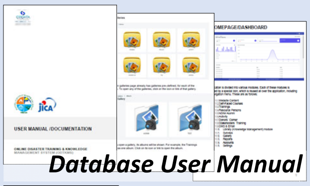
Training Cycle



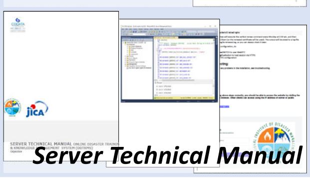
Training Manuals on Disaster Trigger(Slope Disaster)

DATABASE DEVELOPMENT

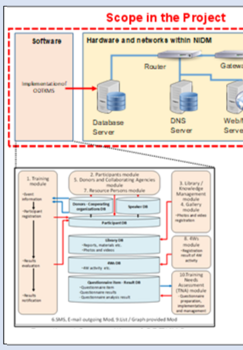
- Development of database for training management
- Creation of a network environment
- Implementation of the "Training on Database Development and Network Environment Operations"
- Development of the Database User Manual and the Server Technical Manual (See the images on the right)



Database User Manual



Server Technical Manual



System Overview Diagram

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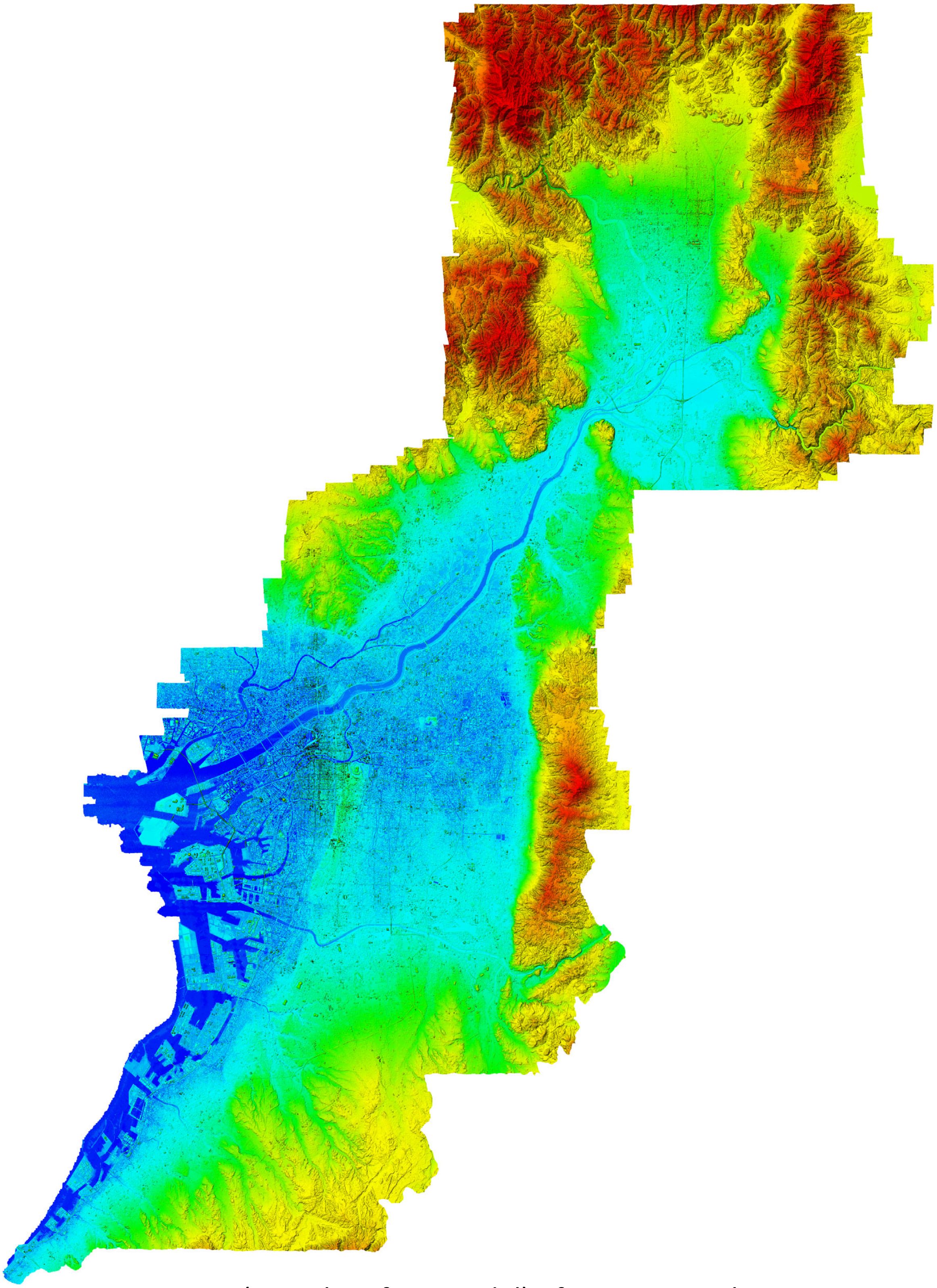
Color Shaded Relief Map (Covering Kyoto to Osaka)
Digital Surface Model (DSM) from Airborne LiDAR

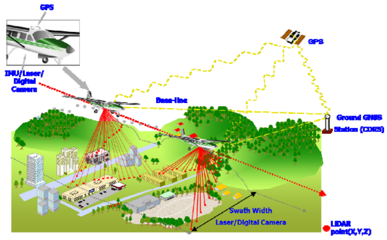
Overview of Color Shaded Relief Map

"Color Shaded Relief Map" on this panel is created using Digital Surface Model (DSM) from airborne LiDAR technology. The DSM data is color coded by elevation values (i.e. Red in higher elevation to Blue in lower elevation) .



DSM (Digital Surface Model) of Kyoto to Osaka area

Airborne LiDAR



Airborne LiDAR Concepts

Aircraft Platform

LiDAR Sensor

Flight Operation

Data Processing

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Slope disaster hazard detection technology using LiDAR* Data

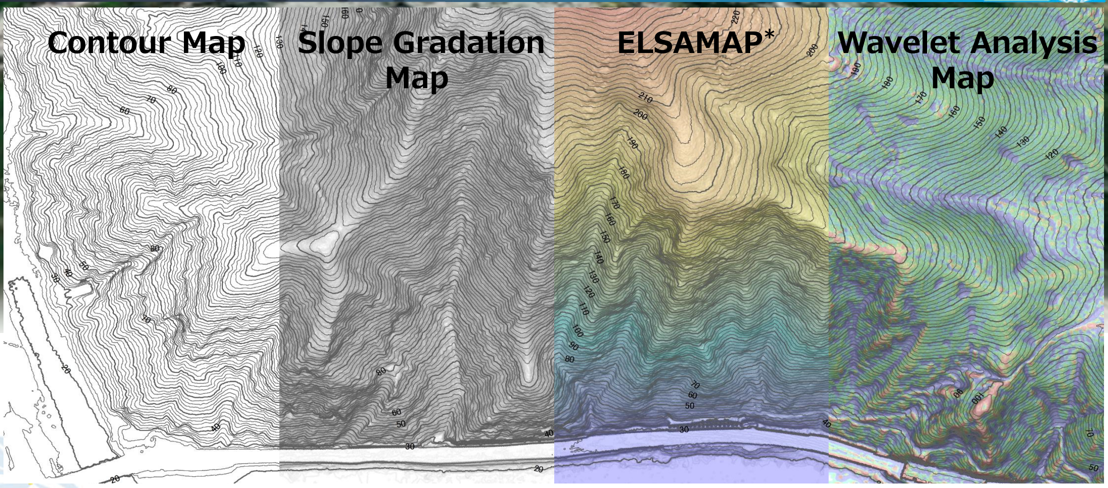
We have a wide range of slope disaster prevention businesses in Japan, where slope disasters frequently occur. Topography, geology, and weather are the main factors of slope disasters, and in particular, topography contains indicators and traces which imply the pre-causes of disasters. For this reason, it is highly important to have an accurate grasp of topography. Thus we are engaging in slope disaster management identifying disaster hazards in slopes by using LiDAR Data techniques. Here, several of these are introduced.

***LiDAR: Light Detection and Ranging technology**

Diversified Presentation of Topography

- ◆Techniques and knowledge enabling the visualization of slope disaster hazards
- ◆Many kinds of mapping techniques employed in slope disaster management
- ◆Measurement techniques and processing technology for high resolution data over wide areas

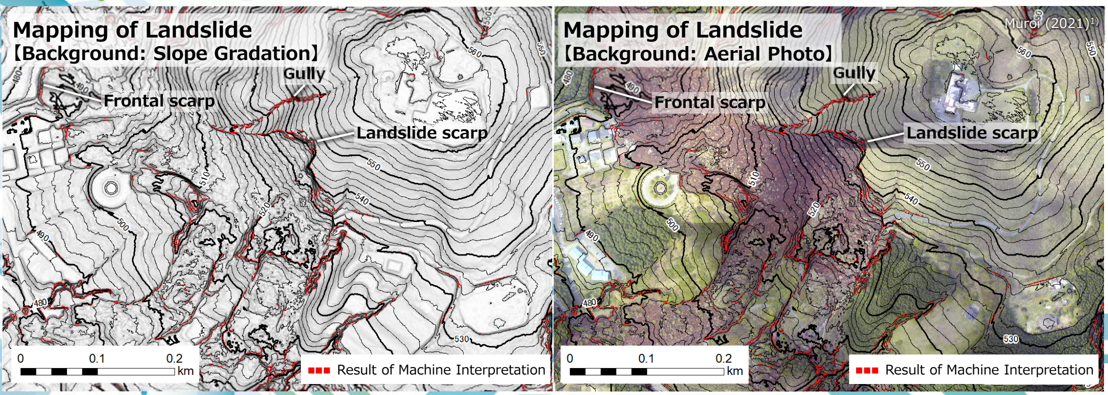
＊**ELSAMAP** (Elevation and Slope Angle Map)
Patented technology which enables three-dimensional visualization of topography by synthesizing the colored elevation model and mapping of slope degree.



Machine Interpretation* of Slope Disaster Hazards (Landslides, and more.)

- ◆Identifying slope disaster hazards with machine interpretation based on geomorphology
- ◆Securing stable quality in identifying slope disaster hazards
- ◆Enabling low-cost analysis

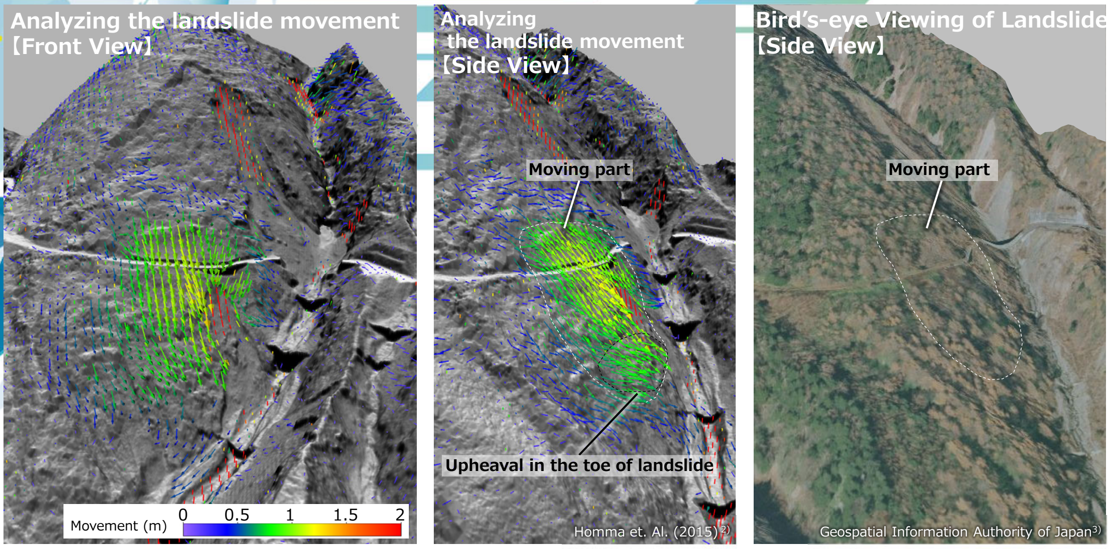
＊**Machine Interpretation**
Patented technology which enables the identification of topography changes in three-dimensional space, such as landslide scarp, weathering fronts, nick lines, and anti-nick lines



Detection of variation in vectors (3D-GIV*)

- ◆Three-dimensional visualization of distance and direction of landslide movement using the data-matching technique of two different points of time.
- ◆Extracting the hazardous area
- ◆Clarifying the movement mechanism of landslide

＊**3D-GIV** (3D-Geomorphic Image Velocimetry)
Our patented technology which quantifies the landslide movement in three-dimensions by tracing the topographical characteristics in the images with different multiple points of time.



Reference
1) Shota Muroi (2021) : Machine detection of slope breaks from airborne laser scanning data, Association of Precise Survey and Applied Technology, No.114, pp.15-22
2) Shin'ichi Homma, Takumi Sato, Yoko Kobayashi, Sakae Mukoyama, Ken'ichi Yanagisawa and Naotaka Momose (2015) : Analysis of Ground Deformation used Digital Geomorphic Image Matching - A Case Study of Analysis at Nomatazawa in Nagano Prefecture -, Abstract Japan Society of Engineering Geology 2015, pp.159-160
3) Geospatial Information Authority of Japan, https://maps.gsi.go.jp/development/ichiran.html

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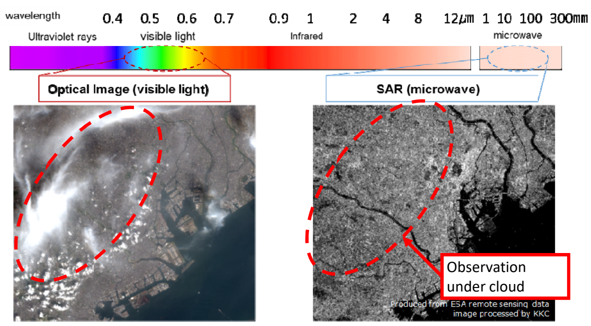
SAR satellite-based monitoring service

SAR satellite

※SAR（*Synthetic Aperture Radar*): A sensor that irradiates the ground with microwaves and observes the ground surface based on the strength and phase of the reflected microwaves. Able to penetrate through clouds and observe even at night or in the rain



- Able to observe land subsidence or large structural displacement
- Able to achieve higher accuracy by combining with GNSS monitoring system
- Able to detect surface based displacement amount and location, and help to grasp specific structure or area displacement by using time series analysis of SAR data

Merits of using SAR data based monitoring

① Efficient and economic survey

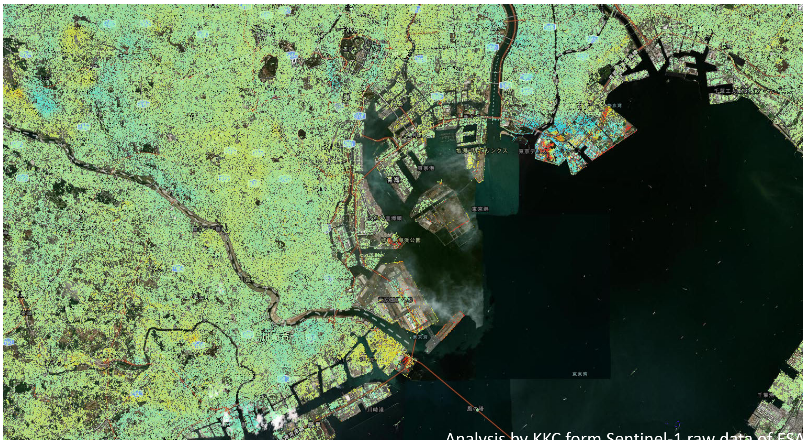
Wide area observation in single time is possible. Additionally, comparing and combining with level surveying, the cost reduction can be reduced in site such as large area where dense survey is required. This merit helps to continue the feasibility of survey.

② Area based monitoring

Using satellite data, area based subsidence monitoring is possible. It helps to grasp new information regarding land subsidence in addition to the conventional high-precision levelling such as finding new subsidence areas, planning of levelling points etc.

③ Historical data availability

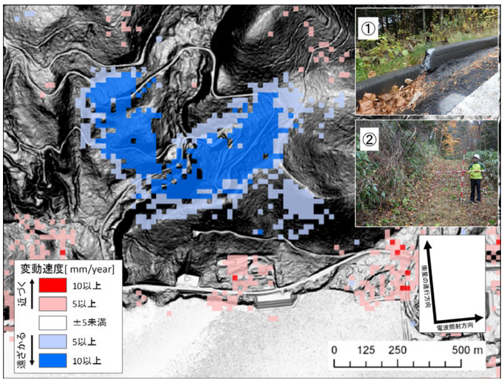
Satellite data has accumulated historical data archive helping to monitor displacement from past. In future, Satellites such as ALOS-2/PALSAR-2 etc. with improved applicability, are planned to be launched, enabling better continuous displacement monitoring.



Large area such as Kanto region can be utilized to monitor ground displacement (Red index in InSAR map above indicates subsidence. Subsidence place such as Haneda airport runway can be seen due to land reclamation)

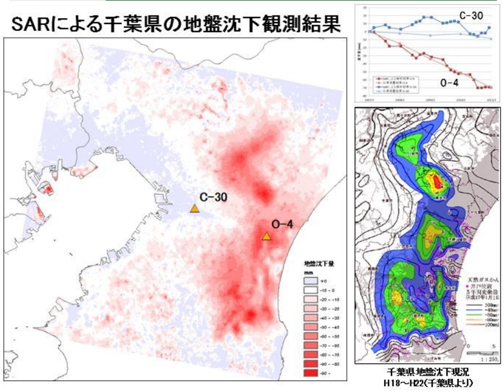
Case studies

① Landslide detection using InSAR



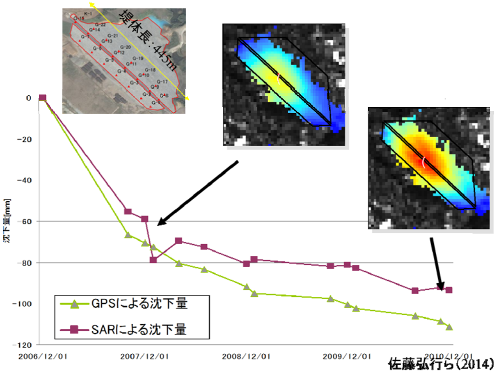
During landslide, the large boundary of displaced area was obtained using InSAR. Later site survey confirmed provided various displacement area. Additionally, new area with displacement was also discovered using InSAR.

② Long term monitoring of land subsidence



Conventional method is limited to provide data from the present point of its deployment. But SAR data, using its historical archive data, enables to monitor ground displacement from the past to present. IT helps in continuous and long-term monitoring as well.

③ Structural displacement monitoring of large structure



A case study of InSAR analysis for structural displacement monitoring of rockfill dam. using 14 scenes of data. The result of displacement trend was confirmed similar to GPS based monitoring. and was able to do area wide monitoring

Broad application scope

- Kokusai Kogyo is providing InSAR based monitoring for long-term monitoring of land subsidence, crustal displacement post earthquake, large-scale structures, land displacement from landslides etc.
- The Cabinet Office- Strategic Innovation Program (SIP) considered the application of InSAR to monitoring of dams, embankments, port structures, etc., and expected that the application scopes of InSAR will expand significantly in the future.

For those who have following requests / issues

- Need to confirm the effect on urban ground with public value announced
- Need to study impact on large structure such as dam after earthquake, flood etc.
- Time series based displacement monitoring of particular structure/ area

※Suitable displacement monitoring methods according to the observation data status, monitoring target, budget, and required accuracy

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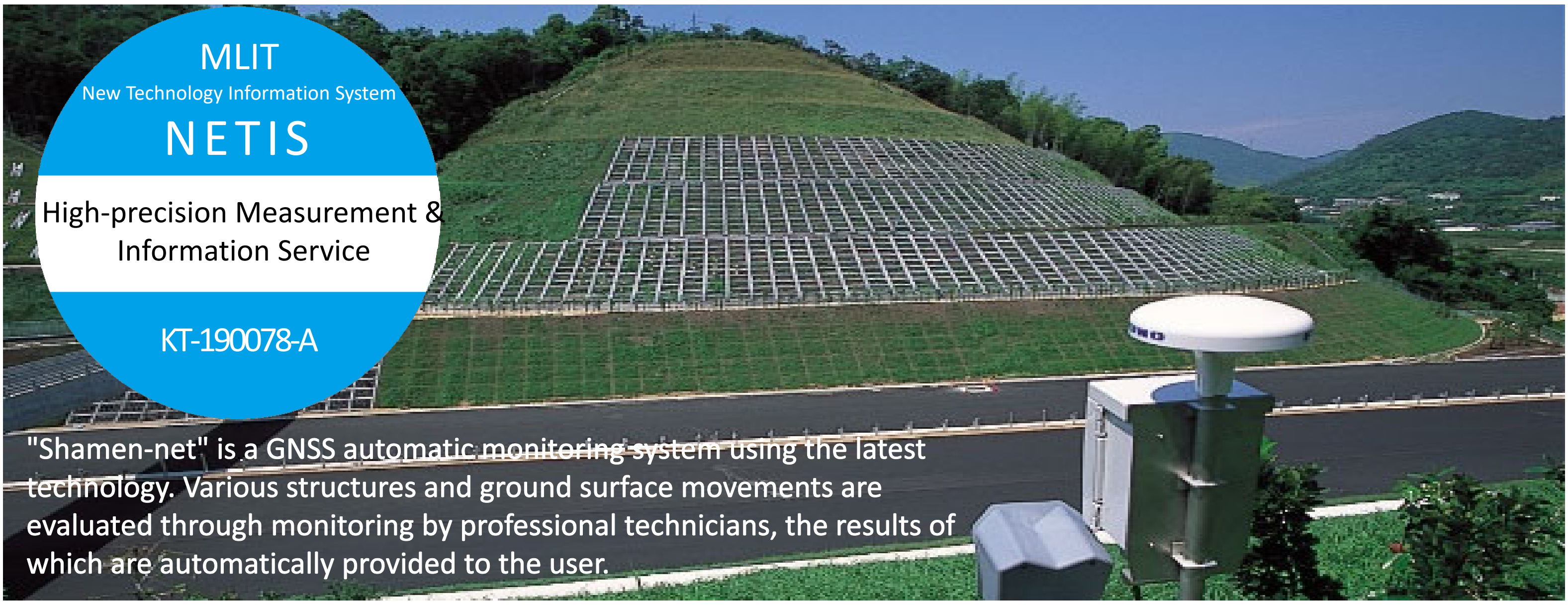
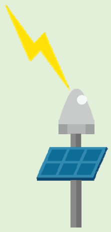
GNSS High-precision Measurement & Information Service “Shamen-net”



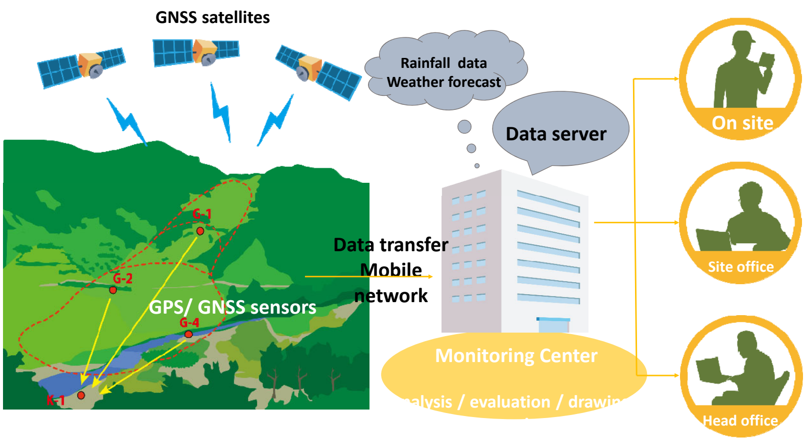
"Shamen-net" is a GNSS automatic monitoring system using the latest technology. Various structures and ground surface movements are evaluated through monitoring by professional technicians, the results of which are automatically provided to the user.

Benefits of GNSS monitoring



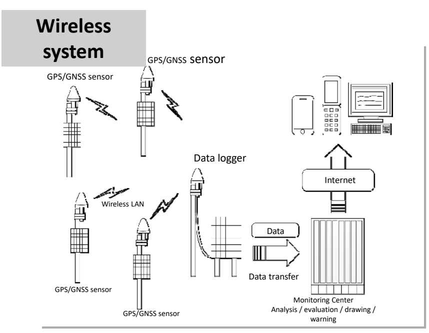
- Displacements of ground surfaces and structures are measured and provided via the Internet.
- The GNSS sensor is installed at the measurement target point and continuously acquires the displacement.
- Highly accurate 3D measurement is realized by using a unique time series statistical processing method.
- Professional technicians constantly monitor displacement data 24 hours a day / 7 days a week / 365 days a year.
- If an abnormal displacement is observed, “Shamen-net” will promptly notify the user by e-mail.

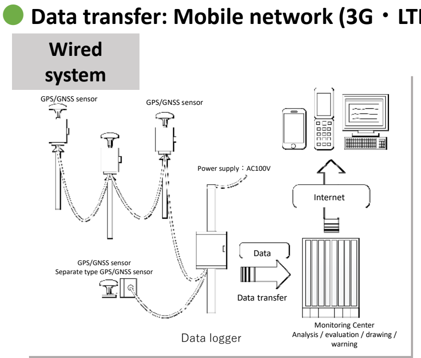
GNSS monitoring / warning system



System configuration

- GNSS: Static, RTK (Real-Time Kinematic)
- Interval: 1 hour (static), 5 minutes (RTK)
- Power supply: AC100V or solar power supply
- Data transfer: Mobile network (3G・LTE)





Installation method according to the site situation

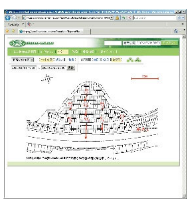

Concrete base

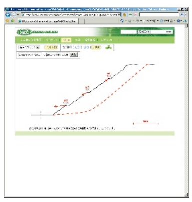

Simple installation using a tripod

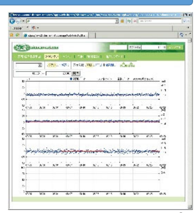

Installation using tall steel pipes


Buried installation at the top of the dam

Example of Internet display image


Horizontal displacement vector


Cross-section displacement vector


Time series graph of displacement

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Vxshu#orqj#krul}rqwdo#frqwuro#gulooloqj（IVF0433）

Drill machine: FSC-100 (made by KOKEN)

◆A drill machine that incorporates a downhole motor as power（KOKUSAI KOGYO owns one）

Advantage of FSC-100

① Drilling of over **1000 m** is possible at a drilling speed of about **30 m / day** (drilling with a tricone bit).

② The drilling **direction can be controlled** by adjusting the vent angle near the tip of the downhole motor.

③ **Geological judgment of the ground is possible** by analyzing mechanical data during excavation and observing excavated rock fragments.

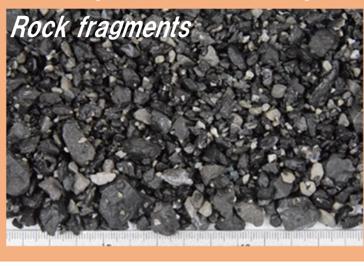
Downhole motor

- Tip drive by high-pressure water flow
- Drilling is possible with little energy loss even at great depths
- The drilling direction can be controlled by excavating using a vent sub

Downhole motor

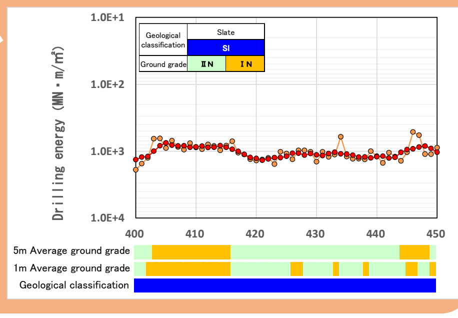
Machine panoramic view ①

Machine panoramic view ②



Rock fragments

Ground judgment result by machine data analysis→

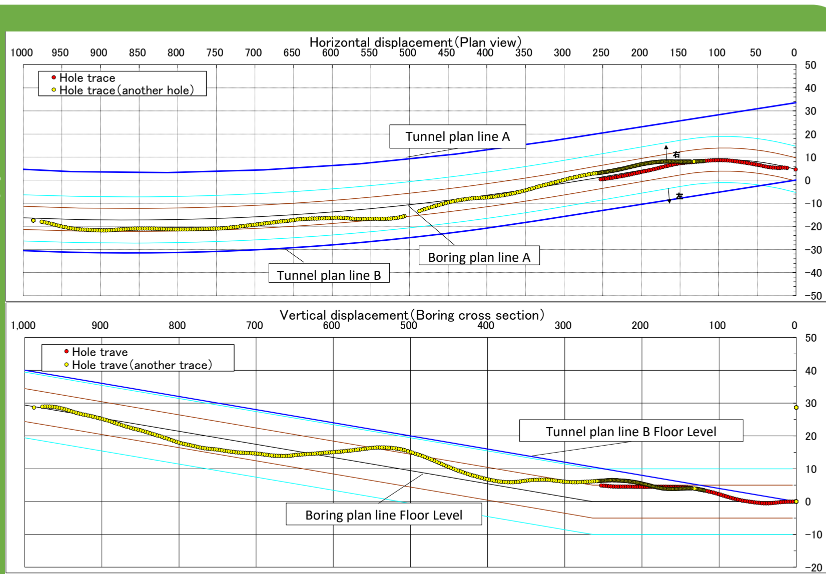


Direction control and hole bending measurement

◆A directional measuring instrument using a magnetic orientation and gravitational acceleration sensor is installed in the downhole motor.

◆Measure the drilling direction while excavating through a special boring rod equipped with a communication function

Excavation is possible with an accuracy of ± 10 m from the planned alignment



Example of hole bending measurement result

Performance of FSC-100					
Size L × W × H (mm)	Mass (kg)	Drive system	Maximum drilling ability (m)	Stroke length (mm)	Spindle inner diameter (mm)
7,780 × 1,950 × 1,730	9,500	All hydraulic type	1,200	3,600	ϕ150

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