

HDS027-01

Room:301A

Time:May 25 08:30-08:45

Rainfall induced rockslides with landslide dam at the course of Miyagawa River, Mie Prefecture, Japan

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Heavy rainfall by the Typhoon Meari (No.0421) caused many landslides at the southern and central Mie Prefecture. Landslide dams were formed by large ones of them. Two cases of landslides and dams occurred at the Miyagawa Valley are described, and their characteristics are discussed.

Rockslide occurred at a tributary of Kasugadani has the volume of 330 million cubic meters. Thick chert lies on mudstone accompanied by felsic tuff and sandstone. The strata of the Chichibu Belt are gently tilted to the direction of the slope. The chert layer is loosened and becomes permeable, while the mudstone layer is less weathered and impermeable. It is inferred that such contrast of rock mass characteristics made the sliding surface at the geological boundary. The sliding mass flowed down 1.0 kilometer along the tributary and dammed the stream of Kasugadani. In the transportation area, hummocks with vegetation composed of large chert blocks are distributed. Thus the movement of the mass is inferred to be debris avalanche. The landslide dam has the dimension of 15 meters high and 75 meters wide.

Rockslide at Mochiyamadani has the volume of 300 million cubic meters. Here, porous limestone breccia promoted by weathering collapsed. Mudstone underlies, but it is uncertain whether the sliding surface exists along the geologic boundary or through the limestone breccia. The strata incline to the slope. The rotated sliding mass dammed the stream of Mochiyamadani with 40 meters high and 60 meters wide. Then a part of the sliding mass flowed to 0.5 kilometers with hummocks.

Mechanism of rockslide and movement of debris avalanche are common to the two cases. Also rapid sedimentation of upstream is common including the other cases of landslide dams formed by the rainfall, which implies that the landslides occurred right after the culmination in the state of rich sediment load. Rainfall induced landslides and dams both of the 1889 Totsugawa case and 1953 Aridagawa case were formed a half or two days after the peak of precipitation. The reason why such early collapses occurred in the 2004 Miyagawa case is uncertain. However, influence of antecedent precipitation and earthquake recorded intensity of 4 on JMA scale before 24 days is possible cause.

Keywords: rockslide, landslide dam, heavy rainfall, Typhoon Meari (No.0421), Miyagawa

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HDS027-02

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An analysis of shallow landsliding at Shobara 2010 disaster using a rainfall infiltration-slope stability model

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This study examines hydrological processes for shallow landslide initiation at Shobara disaster caused by heavy rainfall on 16 Jul 2010, using a rainfall infiltration coupled slope stability analysis. Hydro-geotechnical properties of soils were measured by in-situ shear testing and laboratory permeability tests for undisturbed samples. Slip depths and slope angles were obtained from airborne laser scanning conducted just after landsliding. We simulated one-dimensional vertical pore-pressure propagation due to infiltration into a soil column resulting in rapid increase in pressure head and hence abrupt decrease in factor of safety at soil base. Records of 10 min-rainfall at both of landsliding and non-landsliding areas were used as input for the simulation. The results imply that short-lasting but high-intensity rainfall peak (44 mm/10 min on the record) at the end of the storm event triggers the shallow landslides. Several verbal evidences from residents and time of emergency call-ins coincide with the simulated timing of the landslide occurrence, which support the validity of our modeling.

Keywords: shallow landslide, rainfall infiltration, slope stability analysis, airborne laser scanning

HDS027-03

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Rainfall-induced Landslide Monitoring Using Self-potential Approach

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Landslides are one of the most severe natural disasters in the world and there are two types; rainfall induced landslides and landslides triggered by an earthquake triggering. In China, Korea, and Japan, landslides frequently happen with heavy rainfall and make many losses of lives, houses, roads, railways, and lifelines such as power, gas, water, etc. In this proposal, basic study on early warning system for landslides will be investigated to understand landslide process through hydrological and electromagnetic changes. The final goal of the project is to develop a simple methodology for landslide monitoring/forecasting using self potential method in the frame work of joint research among China, Korea, and Japan.

The proposed project is developing a new scientific and technical methodology for prevention of natural soil disasters. The outline of the project is as follows; (1) basic understanding on the relationship between resistivity distribution and moisture in soil and their visualization of their dynamical changes in space and time using tomography technique, (2) laboratory experiments of rainfall induced landslides and sandbox for practical use of the basic understanding, (3) in-situ experiments in China, Korea, and Japan for evaluation. In consideration above, integration of geological, hydrological, geotechnical characteristics with electromagnetic one are essential. Furthermore, systematic procedure will be taken such as differences in soil and mean radii of soils. For the laboratory experiments of rainfall induced landslide, we use the equipment at Forest and Forestry Product Research Institute, Tsukuba, Japan.

Conventional methods to monitor landslides are based on geotechnical and hydrological approaches to measure pore pressures and displacement on the surface. In these methods, boreholes are required in general and may disturb the subsurface water system. Making boreholes causes a higher cost for monitoring and it is not so practical for field applications. On the other hand, self potential measurement to measure the surface potential difference using two electrodes is easy to set up and measure continuously. If the distribution of resistivity under the ground or soil moisture changes can be detected and can be visualized in space and time, we can have the remote sensing technique for monitoring the soil moisture or water content in the ground. The main purpose of this proposal is to establish a simple system for landslide monitoring/forecasting (early warning system) using electromagnetic approach through basic understanding on electromagnetic property based on hydrological, geotechnical, and geological changes.

HDS027-04

Room:301A

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Observing topographical displacement of the slope and distributing real-time hazard information in Ubayu hot spring

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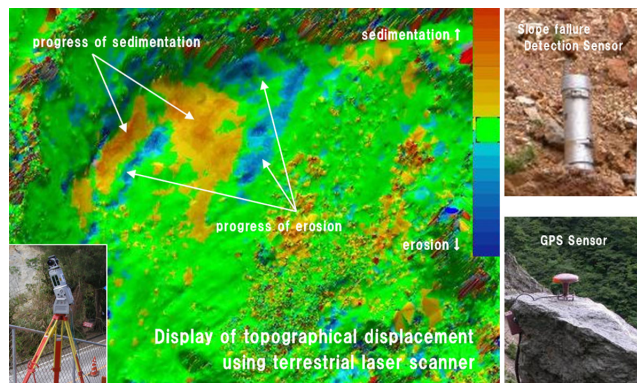
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Ubayu hot spring area is located in the southeast of Yonezawa-city, Yamagata-prefecture. Bedrock is extremely weathered and altered by hot spring alteration in this area. Instability of slopes caused by continuous rock fall and slope failure is going on. Because of these, recently, the large slope failure occurred two times. Also, Ubayu hot spring inn is possible to be isolated by sediment-related disasters, because of its location of deep mountainous region.

The objective of this examination is to detect displacement of the slope related to slope failure, just before or just after, and providing warning information for the people in order to let them make self decision regarding evacuation.

The following were examined:

- 1) Testing two times of highly precise survey measurements using terrestrial laser scanner. Visualizing the topographical changes for the past two years by analyzing the survey data.
- 2) Installing highly precise GPS sensor and observing topographical displacement of the slope continuously.
- 3) Installing real-time slope failure detection sensor and monitoring slope failure directly.
- 4) Installing the rain gauge and considering relations of topographical displacement and the rainfall.
- 5) Providing real-time hazard information of monitoring observation, and it was enabled to share information.



Keywords: Laser Scanning, Increment, GPS Sensor, Slope failure Detection Sensor

HDS027-05

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Effect of global warming on the hazard of sediment-related disasters in snowy regions of Japan

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The area along the Sea of Japan is known as one of the world's heavy snowfall regions, and is likely to be affected by global warming because of the low latitude of the Warm Temperate Zone. The changing snow environment is likely to affect the hazard of sediment-related disasters such as slush flows and meltwater-induced landslides. Therefore, we examined the effect of global warming on the hazard of sediment-related disasters in the snowy regions of Japan.

To clarify the mechanism of sediment-related disasters and evaluate their hazard, the water reaching the ground surface (MR) should be observed throughout the year. We conducted perennial field observation of MR using lysimeters, not only during the non-snow cover season but also during the snow cover season in a mid-land area where sediment-related disasters such as landslides occur frequently. The results of observations showed that the timing and intensity of MR vary depending on the large deviations in the seasonal snowpack environment.

In comparison with the heavy snow season and the light snow season, a high intensity of MR was observed at the beginning of snow cover and during the snow-melting period, and a large quantity of MR was recorded almost every day just before the snowpack disappeared. In the case of the light snow season, the snow accumulation was thin even in the coldest season of January or February. MR was observed intermittently throughout the snow-cover period and a large MR of 60?70 mmd⁻¹ was recorded even in mid-winter.

Global warming will not bring a light snow environment but will lead to larger oscillations between heavy and light snow environments compared with at present. Therefore, in a heavy snow season, huge amounts of accumulated snow will remain till April and May when the air temperature and solar radiation increase rapidly, resulting in a higher hazard of sediment-related disasters with a longer time delay than usual. In a light snow season, MR will be observed in mid-winter in January and February due to the substitution of rainfall for snowfall and intense snowmelting, resulting in a high hazard of sediment-related disasters during this period. Therefore, the hazard of sediment-related disasters is likely to vary greatly as a result of global warming.

The regime of rain on snowpack and meltwater generated on the snow surface change during the infiltration processes of snow accumulation. If it rains with high intensity and short duration on snowpack, a regime of water from the bottom of the snowpack is transformed into low intensity and longer duration due to the buffering function of the snow. Therefore, the rainwater reaches the ground surface in a similar form of rainfall as when there is little snow accumulation.

The intensity and duration of MR affect the quantity of water infiltrating the ground. MR with moderate intensity but longer duration could infiltrate the deeper underground with larger amount of water and generate excess pore pressure resulting in deep-seated landslides. On the other hand, MR with short duration but high intensity may cause shallow landslides and debris flows. Therefore, the type and form of sediment-related disasters are expected to change since the precipitation and snow environment will fluctuate heavily as a result of global warming.

Keywords: global warming, snowy regions, sediment-related disasters, meltwater and/or rainfall

HDS027-06

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Debris avalanche deposits in historical-time found from the east side of Mount Ho-ou, the Akaishi Range, central Japan

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Some landforms-deposits reported from the Japanese Alps in central Honshu Island have been believed to be formed directly by glacial processes during the Pleistocene. However, recent reappraisal of these landforms-deposits indicates that these features had been produced and deformed by landslides in Holocene. This involves reevaluation of climatic geomorphology and Quaternary geology as well as paleoenvironmental reconstruction in mountain areas. Furthermore, this also causes a stir in disaster reduction and prevention related to the wide range of landslides. At this meeting, the author will describe the details of the debris avalanche deposits (DA) found from the east side of Mount Ho-ou, the Akaishi Range, central Japan. This DA has been considered to be formed by ice-mass collapse during the global Last Glacial Maximum (tied to MIS2), resulting in prominent river aggradation of the Komugawa River (the upper Fujigawa-Kamanashigawa River system). However, the following evidences and conclusions were obtained: 1) DA consists of a thick gravel layer with granitic rock clasts only although the present-day DA lies in a sedimentary bedrock area. 2) Rock clasts have characteristic auto-brecciated or jigsaw puzzle structure suggesting strong deformation by mass rock creeping and subsequent mobilization. 3) Humic soils with wood fragments are buried immediately beneath DA. 4) DA is covered by fluvial fine sand with wood fragments along the main river, probably introduced by natural-dam obstruction. 5) Wood fragments (total 5 samples including one sample by previous study) gave the ages ranging 770-990 cal AD and 670-890 cal AD. 6) Volumetric magnitude and H/L ratio of DA are estimated to be $1.8 \times 10^7 \text{ m}^3$ and 0.32, respectively. 7) The possible cause of DA was historical earthquakes ($M > 6.5$) such as AD762 Mino-Hida-Izu Eq, AD841 Shinano Eq, AD841 Izu Eq and AD887 Goki-Shichido Eq. Either Mino-Hida-Izu Eq or Shinano Eq is believed to be the last event of the nearby Itoigawa-Shizuoka Tectonic Line active fault zone several kilometers east of Mount Ho-ou. Izu Eq could be attributable to the penultimate activity of the Tanna fault in Izu Peninsula, 120 km southeast. Goki-Shichido Eq. is considered to be caused by plate subduction along Suruga-Nankai Troughs, and it led to sector collapse and a natural-dammed lake in Yatsugatake Volcano 50 km north of the Mount Ho-ou.

Keywords: Debris avalanche, Pleistocene glaciation, Landslide, Historical earthquake, Paraglacial

HDS027-07

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Landslides in Hokkaido,2010

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Many disasters by slope failures and landslides, besides river floods, occurred in Hokkaido during a summer season in 2010 caused by frequent local heavy rains. Slope failures triggered by earthquake (December 2, Kiyota, Sapporo, MJ=4.6) also happened. We show some cases of these slope failures with their geologic background.

(1) August 13-14, Teshio and Enbetsu towns in northern Hokkaido: A lot of slope failures occurred at hillslopes and slopes in a low-relief mountainous area. Most of the slopes are consists of fine-grained sandstone and mudstone interbeds of the Pliocene Yuuchi Formation, and subsequently consists of diatomaceous mudstone of the Miocene Enbetsu Formation. The failures show transitional movement from surficial slide to debris flow. Some cases, at the slope consists of the Enbetsu Formation, show movement type of weathered-bedrock failure to debris flow (Ishimaru et al., 2011).

(2) August 22, Nokanan, Ashibetsu City in central Hokkaido: A landslide occurred at a slope consisting of mudstone and tuff of the Cretaceous Yezo Supergroup.

(3) From August to present, Kamikubonai, Sobetsu Town: A relatively small landslide, 250 m in width and 350 m in length, arose at a slope of the Toya pyroclastic deposits and underlying Neogen mudstone and tuff. Persistent displacement of 1 cm/day has been observed after a heavy rain in December 3.

(4) December 2, Kiyota, Sapporo City: Slope failures occurred in a golf course above the epicenter of the earthquake (MJ=4.6). The golf course was developed on a hill area consisting of the Shikotsu pyroclastic flow deposits. Two failures happened at artificial embankments built in the brook. One of slides show large displacement suggesting flow-type movement.

Keywords: landslide, geologic cause, heavy rain fall, earthquake

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HDS027-08

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Landslides on artificial slope in city center of Naha

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Landslides in Shuri, Naha were caused by severe rain storm in 2004. The Landslides developed on artificial fill slope (embankment) after WW2. The mechanism of the landslides was discussed.

Keywords: landslide, embankment, interaction, Naha

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HDS027-09

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Sagging geomorphology on ridges along the Fukui-Gifu prefecture boundary, central Japan

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We describe sagging geomorphology such as double ridges and uphill-facing scarps on the ridges along the Fukui-Gifu prefecture boundary, and discuss their relationship with the geologic structures of this area by using contour maps and 'Inyouzu' made from the DEM data with 1 m-mesh density; the data and maps were provided by the Etsumi Sankei Sabo Office, Chubu Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism. In the study area occur chert, melange and basalt of the Mino terrane, Neogene andesitic lava and volcanoclastic rocks of the Ito-o Formation, and Neogene Nogohakusan granodiorite. Total distance of the ridge analyzed is 49.8 km, where 182 sites of sagging geomorphology with total length of 8.9 km are recognized. The distribution of the sagging geomorphology in the volcanic rocks and granodiorite area is dense, whereas in the chert and melange is sparse. Although most of the double ridges are parallel to the orientation of main ridge, some uphill-facing scarps are oblique or perpendicular to the ridge. Large-scale uphill-facing scarps were formed in case that the attitude of bedding is parallel to the orientation of the main ridge. Carbonaceous materials and sediments have been accumulated in most of the linear depressions between the double ridges and between the uphill-facing scarp and the slope. Analyses of these sediments in future must reveal the development history of the sagging geomorphology in this area.

Keywords: sagging geomorphology, double ridge, uphill-facing scarp, Fukui, Gifu

HDS027-10

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Gravitational slope deformation and catastrophic landslide controlled by the incision of a paleosurface

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Huge landslides have been occurring in tectonically active mountains, where uprising and river incision form gravitationally unstable state in mountain slopes. In particular, when a paleosurface is incised, large volume instability is likely to be induced, because convex, projecting slopes are consequently made. We found large gravitational slope deformations induced by these processes in several locations, particularly in the upstream area of the Totsu River in the Kii Mountains in the outer belt of Southwest Japan, the Dahan River catchment, and the Chishan River in Taiwan. Our study includes chronological development history. Fluvial incision of a paleosurface makes a knick point, which recesses upstream, cuts the foot of side hillslopes of paleosurface, destabilizes the slopes, and then gravitational slope deformation starts on outfacing slopes.

We identified a paleosurface with an average slope of 33 degrees in elevations higher than about 650 m, which paleosurface is incised by a river to form inner valleys with a maximum height of 250 m of side slopes. This paleosurface is not a peneplain proposed by Davis but is steep with moderate relief. On the infacing slopes of inner valleys, convex slope breaks have been made, and on the outfacing slope, gravitational deformation has been induced by the undercut. Our reconnaissance study suggests that similar slope development occurred in the outer belt of Southwest Japan in Shikoku and Kyushu, where have similar tectonic background. Large landslides, which were induced by the 2005 rainstorm in the Mimi-River catchment in Kyushu, occurred in the inner valleys incised in the Shimanto terrain

We found paleosurfaces in higher elevations of the Neogene area in the Dahan River catchment. They are incised by rivers to form convex slope breaks and inner valleys. The distribution of gravitational slope deformations and landslides are closely related to the slope breaks, suggesting that they are controlled by the slope development as stated above. The Shiaolin landslide, which was induced along the Chishan River by the typhoon Morakot in 2009 in Taiwan, also occurred on the gravitationally deformed slope along the edge of a paleosurface.

Keywords: paleosurface, incision, gravitational slope deformation, landslide, slope failure

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HDS027-11

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Slope destabilization induced by river rejuvenation in Shihmen reservoir watershed, northern Taiwan

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Steep incised landscape of Shihmen reservoir watershed was sculpted by rapid uplift and erosion in a tectonically active setting in northern Taiwan, where geomorphic features such as knickpoints, terraces, slope breaks and paleosurfaces are developed. We conduct field investigation and analyses of a 12-m DEM to study the distribution of the geomorphic features and to integrate slope development, gravitational deformation, and landslide occurrence for the purpose of making hazard zonation map of landslides.

The Dahan River has three major tributaries, which have four or five major knickpoints each, and one knickpoint along one major tributary can be correlated to a knickpoint along another major tributary. This is indicative that knickpoints propagated upstream along the major tributaries. The minor tributaries of the major tributaries also have knickpoints, which could be correlated to each other and to the knickpoints along the major tributaries. This again supports an idea that knickpoints propagated upstream along these tributaries. Corresponding to these knickpoints, there are two groups of convex slope breaks, higher and lower slope breaks. The higher slope breaks bound a paleosurface, which is widely developed in higher elevations in the watershed; the formation and retreat of this group of slope breaks accompanied many large landslides, particularly on the outfacing slopes. The lower slope breaks appear to grade to the terraces traced several tens to a few hundred meters above trunk channels and major tributaries associated with the most recent base-level lowering; many shallow landslides have occurred below these lower slope breaks.

Keywords: river rejuvenation, slope destabilization

HDS027-12

Room:301A

Time:May 25 11:30-11:45

The role of mass rock creep on surface shape revealed by LiDAR.

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Deep catastrophic landslide which bedrock failed might cause large-scale landslide dams and debris flows, and might afford the great deal of harm to around areas. In the study, term of deep catastrophic landslide means rapid landslides and excludes slow failures of a more chronic nature, such as deep-seated gravitational creep or rock flow. The prediction of location of deep catastrophic landslide is important to reduce such sediment disasters. Long-lasting, small-scale mass movements called gravitational mass rock creeps sometimes lead to deep catastrophic sliding. Therefore, it can be thought that the spatial distribution of landforms related to long-lasting mass movements, such as rock creep slopes, downhill-facing scarps and so on, may provide an index for deep catastrophic landslide susceptibility. To clarify spatial distribution of mass rock creep, interpretation of aerial photographs was often used. However, the interpretation of aerial photographs was affected by vegetation and the removals of vegetation effects were very difficult. Also this method needs a lot of skills. On the other hand, the LiDAR develops rapidly in recent years, and can understand detailed surface shapes in the mountainous district where the forest grows thickly. In this study, we used LiDAR data to clarify the surface geometry of the mass rock creep slope and non-mass rock creep slope quantitatively.

The study area is Mt. Wanitsuka in the southern part of Kyushu. In this area, many deep catastrophic landslides occurred by heavy rain in September 2005, seven of which occurred at the slopes where could be found signatures of mass rock creep before occurrence of deep catastrophic landslide. We conducted detailed geological survey and interpretation of aerial photographs clarify spatial distribution of mass rock creep. We derived 2-m grid DEMs used the LiDAR data, and calculated the slope gradient and the eigenvalue ratio. The eigenvalue ratio is an index that expresses a degree the ruggedness on the surface. When the eigenvalue ratio is large, the slope surface is smoothly. In contrast, when the eigenvalue ratio becomes small, the slope surface is large ruggedness and undulate. Moreover, we calculated the slope gradient and the eigenvalue ratio using six additional grid cell sizes (4m, 10m, 20m, 30m, 50m, and 100m).

Slope gradient of mass rock creep was gentle, compared with non-mass rock creep, regardless of grid size. On the other hand, there was a difference in the distribution of the frequencies between mass rock creep slope and non-mass rock creep slope. When we used 2m as grid size for calculation, the difference in eigenvalue ratio between mass rock creep and non-mass rock creep was small. While we used 20-30m, these are large differences in eigenvalue ratio between mass rock creep and non-mass rock creep. However, we used 50-100 m as grid size, the difference became small. The change of the eigenvalue ratio distribution by the grid size indicates the different geometry between the valley and the ridge at the mass rock creep slope and non-mass rock creep slope. That is, the mass rock creep has shallow and rounded valley, and the non-mass rock creep has deep and steep valley. Thus, it can be thought that the mass rock creep slope can be extracted quantitatively by using the LiDAR data.

Keywords: mass rock creep, deep catastrophic landslide, LiDAR data, eigenvalue ratio

HDS027-13

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Result of boring, electrical resistivity and some surveys in the landslide area detected by SAR interferometry

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Using Synthetic Aperture Radar (SAR), Une et al. (2008) revealed 2007 Noto Hanto earthquake (M6.9)-induced landslide that slightly moved east. The landslide covers 1.5km by 700m and lies on anti-dipping gentle hilly slope, and cracks and small landslide were found on the edge of and inside the initial landslide area. In the area we performed boring survey, observed outcrop, and measured electric resistivity on the slope, pH and electric conductivity along a stream. Boring core and measurement result of electric resistivity and pH did not show existence of clear slip surface; however, measurement result of electric conductivity suggested the location of lower end of the landslide area. These results infer that landslide blocks without clear slip surface moved east together at subtle deformation. And result of this study inferred characteristics of earthquake-induced landslide in the study area.

Reference

Une H, Sato HP, Yurai H, Tobita M, 2008, Analysis of surface deformation induced by the Noto Hanto and the Chuetsu-Oki Earthquakes in 2007 using synthetic aperture radar interferograms. Journal of the Japan Landslide Society, Vol.45, pp.125-131.

Keywords: earthquake, boring, electrical resistivity survey, electric conductivity, SAR

HDS027-14

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Deformation process estimate of a remobilized landslide based on IT Ground Tiltmeter observation and displacement vector

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Observing the movement of landslides using ground tiltmeters has been done at many landslide sites, but there are few cases where the rotation speed has been compared quantitatively along with displacement speed. This report introduces a case where the landslide mass deformation process was estimated at a remobilized landslide by using an IT Ground Tiltmeter System, by movable pile observations using an optical distance meter, and by interpreting aerial photographs and topographical maps.

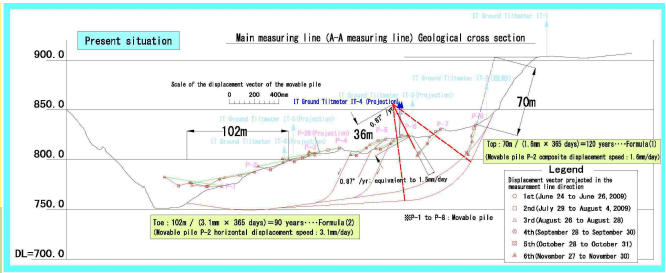
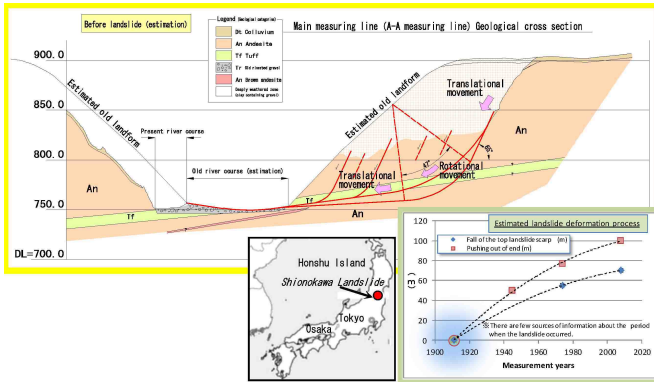
Shionokawa landslide is an active landslide with a clear landslide scarp with relative elevation up to about 70m. The foundation ground and landslide mass are Quaternary andesite, and it is assumed that a 7 to 11m thick tuff layer is, as a weak layer, associated with the formation of the landslide. A boring core found old river course sediments, confirming the past location of the river.

Monitoring using a ground extensometer began in May 2006, and movable pile observations were added in June 2009. Since then, observation data spanning up to 5 years have been accumulated. The ground extensometer in the top of the landslide scarp revealed an annual rate of change of 350mm (about 1.0mm/day), and while the rate of change varies during torrential rain or melting snow, it is almost constant from year to year. If a rough calculation is done based on movable pile observation results, it can be trial calculated that the present landslide topography formed in approximately 100 years: about 120 years at the top where the settlement displacement constituent dominates (formula (1) in the figure) and 90 years at the end where the horizontal displacement constituent dominates (formula (2) in the figure). However, the influence of river erosion at the end of the moving mass is not considered.

A 1:50,000 topographical map for 1911 shows neither river curves nor landslide topography. Aerial photographs taken by the U.S. military in 1945 found both landslide topography and river curves. From these information sources, we identified a river curve at the end and the fall of the landslide scarp of the landslide, and appended a graph prepared by estimating the change.

At the Shionokawa Landslide, *the Research Association for Development of Observation Devices used in Special Landslide Environment* (revised name of the joint research) installed the IT Ground Tiltmeter System developed through joint research by the Public Works Research Institute and 4 private companies (PWRI et. al. 2009) at 6 locations from behind the main landslide scarp of the landslide to its bottom, and used them to perform observations at 1 hour intervals. Excluding one installed behind the main landslide scarp, all recorded tilt change, and both the backward rotation and forward rotation are confirmed by instruments. The largest tilt was recorded by IT-4, where the slide rotated backwards towards the landslide scarp side at a speed of 0.87degree per year (3,117seconds). As the figure shows, if it is assumed that it rotated on a circle with radius of 36m, the rotation is 543mm/year (1.5mm/day), which conforms closely with movement according to the actual movable pile observation (at movable pile P-6, 1.9mm/day).

The landslide mass deformation process from the time of occurrence of the Shionokawa Landslide until now was consistently estimated by combining the displacement vectors obtained by the IT Ground Tiltmeter System and the movable pile observations in this way. In sum, the authors suppose that at first, translation sliding and rotation sliding combined to leave the internal structure unchanged without conspicuous abrupt displacement, as gradual deformation occurred. Judging from change of the section shape, it may be assumed that the safety factor gradually rose and the displacement rate gradually slowed. The application of the IT Ground Tiltmeter System to a remobilized landslide is considered to be very effective in cases with a rotation constituent as at this survey location.



Keywords: landslide, IT Ground Tiltmeter System, rotational slide, displacement vector, deformation process

HDS027-15

Room:301A

Time:May 25 12:15-12:30

Numerical Analysis for Permeability of Clay on Natural Terrane

JungHae CHOI^{1*}, Byung-Gon Chae¹, Katsuyuki Kawamura², Yasuaki Ichikawa³

¹KIGAM, ²Tokyo Institute of Technology, ³Okayama University

A landslide on natural terrane is mainly occurred by rainfall, snowmelt, earthquakes and construction works. Especially, the role of rainfall or snowmelt in slope stability is very important because it causes decreased in shear strength by reducing the soil cohesion. As water content in soil increases, the shear strength in soil or other unconsolidated material usually decrease.

If clay exists in the weathered soil, the physical characteristics such as viscosity and permeability are generally different from the condition without the clay. In this case, changes of permeability or viscosity due to the rainfall or snowmelt are dependent on the content of clay in soil. In order to calculate the permeability variation according to the content of clay in soil, many researchers already investigated using laboratory experiments or in-situ tests in the field. However, it is difficult to determine the property of the clay such as a viscosity because of its poor crystalline property. In order to solve this problem and to calculate permeability of clay under various dry densities, we used molecular dynamic (MD) simulation to examine the viscosity of micro scale and homogenization analysis (HA) method to expand micro material property to macro scale. In this research, we determined the permeability of clay under various dry densities due to the rainfall or snowmelt conditions by using MD/HA method.

We determined the viscosity of micro scale material using the MD because the viscosity is heavily dependent on the amount of interlayer water and it cannot be calculated by the experimental method. And then, in order to calculate the macro scale permeability of clay under each dry density condition we made a unit model using the result of MD analysis as input data. Finally, macro scale permeability of clay was determined under various dry density conditions using the HA method. we also examined the applicability of the method to the natural terrane including clay.

Keywords: Molecular Dynamics, Homogenization Analysis, Viscosity, Permeability, Clay

HDS027-16

Room:301A

Time:May 25 12:30-12:45

The influence of hydrogeological condition on earthquake-induced rapid and long runout landslides

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In recent decades, lots of landslides were triggered by earthquake and caused severe damages to the society. Earthquake-induced-landslides become a hot topic in natural disaster research field. For example, the 1995 Hyogoken-Nambu earthquake triggered Nikawa landslide and Takarazuka Golf-field landslide, 1999 Ji-Ji earthquake in Taiwan triggered Chaolin landslide and Jiufengershan landslide, 2003 Sanriku earthquake in Japan triggered Tukidate landslide, 2004 Sichuan earthquake in China triggered lots of landslides including Donghekou landslide in Qingchuan county, Wangjiayan landslide in Beichuan county, 2009 September Indonesia Sumatra earthquake triggered lots of flowslides including Tandikek slide and Malalak slide. From those cases, the hydrogeological condition shows strong influence on the initiation and motion of the landslides.

1) Rapid and long runout landslides triggered by 2008 Sichuan earthquake in China

The 2008 Wenchuan earthquake triggered lots of rapid and long runout landslides, which directly caused great loss of property and human lives and were responsible for a large percentage of total damages caused by the earthquake. It was found that groundwater and valley water played key roles in the rapid motion and long runout process of this landslide during the great earthquake. It was also observed that hazardous effects from the slowing of movement and/or a short runout, due to various geologic and hydrologic conditions of other landslides caused by the Wenchuan earthquake, contrasts with those which caused more deaths and damage due to rapid, long runout movement.

2) Tandikek and Malalak flowslides triggered by 2009.9.30 Sumatra earthquake in Indonesia

Earthquake activity is intense in southwestern Sumatra. Four major earthquakes occurred in the area between 2004 and 2009. The first and largest of these was the M9.3 earthquake that occurred on 26 December 2004. This earthquake caused a major tsunami disaster over a wide area, and 227,898 people lost their lives. A M8.6 earthquake occurred on 28 March 2005, followed by a M8.5 earthquake on 12 September 2007, and a M7.6 earthquake on 30 September 2009.

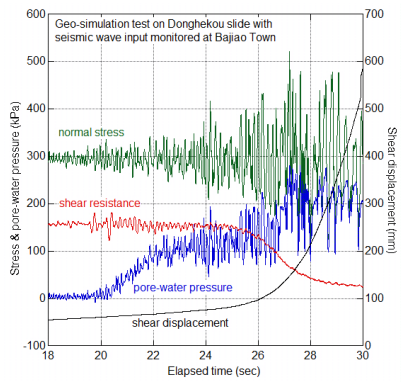
The 2009.9.30 M7.6 event was the smallest of these earthquakes, but it triggered many flowslides in the mountainous areas of Tandikek and Malalak. Those flowslides rapidly moved down slope, destroying villages at the fronts of the slopes, and killing many villagers. The distance from the epicenter is about 100 km. Padang is located almost midway between Cumanak and the epicenter. Among the landslides in the area, the Tandikek and Malalak flowslides caused most deaths. The common features of the two flowslides is that both occurred on steep source slopes of 30 to 40 degrees, movement was rapid, and villages located at the foot of the slopes were destroyed. This led to 132 and 32 fatalities at the Tandikek and Malalak flowslides, respectively.

Field investigation and ring shear tests indicate that, 1) Steep slope in the source area slope; 2) Continuous rainfall for three hours; 3) The strong seismic motion from the M7.6 earthquake; 4) The special structure, with the pumice layer overlying a stiff clay layer formed worst combination for flowslides.

3) Conclusions

Case study on Donghekou landslide triggered by 2008 Sichuan earthquake indicates the importance of hydrogeological condition on landslide initiation and motion. While case study on Tandikek flowslide and Malalak flowslide triggered by the 2009.9.30 M7.6 Sumatra Earthquake during rainfall shows that the worst combination of the following factors is the main reason for the flowslide occurrence and their rapid motion.

Through this study, we aim to call attention to similar slopes elsewhere. It is crucial to recognize the potential danger in those slopes, and locate the local residents in safe places.



Keywords: earthquake, landslide, hydrogeological condition, case study

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HDS027-P01

Room:Convention Hall

Time:May 24 16:15-18:45

Effect of geology on the landslides by the Iwate-Miyagi Inland earthquake in the upper reach of Ichihazamagawa River

Hiromu Daimaru^{1*}, Wataru Murakami¹, Yasuyuki Tada¹, Takashi Okamoto¹, Toshiaki Sanmori¹, Fumitoshi Esaka²

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We studied on the stratigraphy and geological structure by field survey and interpretation of airborne LiDAR DEM for the upper reach of Ichihazama River, where many landslides occurred by the 2008 Iwate-Miyagi Inland Earthquake. The Quaternary Kitagawa Tuff with high density and many cooling joints acts as caprock which was underlined by the Tertiary soft and low density sedimentary rock (Onomatsuzawa Formation).

In the northern part of the study area (north of the mouth of Kawaragoya-zawa River), ancient mountain landform was buried by the Kitagawa Tuff and the base level of the caprock was significantly high, which presumably brought about many large deep-seated landslides by the earthquake. Most of the deep-seated landslides by the 2008 earthquake have occurred on the steep slopes along the rivers and no large landslide occurred on geological dip slope, which has prevailed in Aratozawa and Koei Areas. The roughness of the caprock basal plane has affected on the motion of mountain slope to the characteristic features of the landslide.

Keywords: Iwate-Miyagi Inland Earthquake, landslide, caprock, GIS

HDS027-P02

Room:Convention Hall

Time:May 24 16:15-18:45

Topographic characteristics of mountain slope where landslide induced after 2008 Iwate-Miyagi Nairiku Earthquake

Wataru Murakami^{1*}, Yasuhiro Ogawa¹, Hiromu Daimaru¹, Fumitoshi Esaka²

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Authors have reported that landslide induced newly by the rainfall during 3 months after the 2008 Iwate-Miyagi Nairiku Earthquake, and moreover that cracks induced by the earthquake existed around the new landslide. This report introduces about the topographic characteristics of mountain slope where landslide induced after the earthquake by comparing shaded-relief maps and 1 m-contour maps made from the LiDAR data at two times (immediately after the earthquake and passed the earthquake 3 months), and the result of the field survey, on Tsukinokidaira area of Ichinoseki city, Iwate prefecture.

The micro-topography before the landslides induced after the earthquake occurred was interpreted, by the shaded-relief maps and 1 m-contour maps made from the LiDAR data. As the results, the spots where the landslides occurred after the earthquake was the convex, semi-circular, or horseshoe-shaped low gradient slope area. Such micro-topography was interpreted on several slopes where the landslide had not been generated yet. From the field survey, the occurrence of the cracks was found on these slopes. Around one of these cracks, simple penetration test was carried out. As a result, a weak layer existed in the depth of 2 m from surface in the slope below the crack. Thus, it was guessed that the weak layer was formed with the occurrence of the crack at the earthquake and it had led to the landslide by the rainfall after the earthquake.

Keywords: landslide, crack, LiDAR, low gradient slope area, simple penetration test, Iwate-Miyagi Nairiku Earthquake

Evaluation of earthquake-induced landslide by using multivariate analysis

Bateer Hasi^{1*}, Kiyoteru Maruyama¹, Akira Nakamura¹, Tomoyuki Noro¹, Yoshifumi Hara¹

¹PWRI, Japan

Recent years, a series of strong earthquakes attacked Japan and surrounding regions, caused serious damages, such as destroyed lifelines and blocked rivers due to earthquake-induced landslides. The landslide susceptibility analysis is a method to reduce the landslide damage accompanying strong earthquakes. This study purposes to evaluate earthquake-induced landslide, by focusing on topographical factors using logistic regression analysis. We focused on pre-existing landslide topographies, according to the result that more landslides occurred within pre-existing landslide topographies by the Mid-Niigata earthquake (Has et al., 2009), and the landslide topographical interpretation data are available. In this analysis, we used the landslides data from the Mid-Niigata earthquake in 2004 and the Iwate-Miyagi Inland earthquake in 2008.

Logistic regression analysis is a type of predictive model can be used when the depend variable is categorical and dichotomous. In this study, the landslide occurred /non-occurred is categorical data as dependent variable, and the geomorphological factors that influence landslide occurring are independent variables. Here, we selected surface roughness (the largest value of elevation difference within landslide topography), marginal erosion ratio (the erosion condition around the landslide topography; see Suzuki et al., 2010), slope gradient, mean curvature, distance from ridge line as independent variables which considered to be the influencing factors for landslide induced by earthquake. In this study, we only selected geomorphological factors but did not select geological factors, because the considerable regional differences of the geological factors.

In the analysis, at first, we used 87 landslides occurred by the Mid-Niigata earthquake within pre-existing landslide topographies and randomly selected 87 pre-existing landslide topographies which did not moved by the earthquake. After logistic regression analysis, we selected the most influencing factors and calculated the coefficients. We used logistic regression method of multivariate analyzing software of SPSS Statistics Ver.19 (SPSS Inc.). After using stepwise method to select the topographical factors, surface roughness and marginal erosion ratio are acting as most influencing factors for landslide occurring. After validation, the result showed that 74.7% of landslides correctly predicted in the Mid-Niigata earthquake. Using by the coefficient from analyzing result of the Mid-Niigata earthquake data, we predicted the landslides by the Iwate-Miyagi Inland earthquake, and the accuracy is 77.2%. Based on this result, surface roughness and marginal erosion condition are considered to strongly influence the occurrence of landslide by earthquake. Therefore, we re-analyzed the data from both the Mid-Niigata earthquake and Iwate-Miyagi Inland earthquake; used 116 landslides occurred pre-existing landslide topographies and randomly selected same number of non-occurred pre-existing landslide topographies. The validating result showed, the predicting accuracy is 75.4%.

The result of above analysis suggested the, logistic regression method is useful method to evaluate earthquake-induced landslide. Using this method, we will conduct earthquake-induced landslide susceptibility mapping around active fault.

Keywords: earthquake, landslide, multivariate analysis, susceptibility evaluation, Mid-Niigata earthquake, Iwate-Miyagi Inland earthquake

HDS027-P04

Room:Convention Hall

Time:May 24 16:15-18:45

Study of relationship between earthquake-induced landslide displacement with ground-water condition based on landslide me

Akira Nakamura^{1*}, Bateer Hasi¹, Maruyama Kiyoteru¹, Noro Tomoyuki¹

¹PWRI

As a triggering factor of landslides, strong earthquakes were known to induce large-scale landslides in mountainous region. Due to less measurement data that captured landslide movement at earthquake, the characteristics of landslide behavior are still not clearly understood. So far, there are few reports that collected and documented the displacement of landslide measurement at earthquakes. In this study, we collected literatures that include description about landslide measurement at earthquakes occurred from 1964 to 2007 in inland and offshore of Japanese islands.

We analyzed these data from literatures, revealed some characteristics of landslide sites, including landslide movement, groundwater level and pore water pressure change of at earthquake.

1)Landslides sites where no movement before earthquake, tends to result relatively large displacement, but rarely continues its movement during and after that earthquake.

2)Landslides that acting by rainfall before earthquake, show more displacement during earthquake than before earthquake; but after earthquake, it will become steady in some cases.

3)The depth of displacement of landslides is the depth of slip surface in most of the cases.

4)In most of the cases, the groundwater level or pore water pressure of landslide site increased at earthquake.

5) After earthquake, groundwater level and pore water pressure in landslide site recovered to the level before that earthquake, the period ranged 1 day to 3 months.

According to the above characteristics of landslide displacement at earthquakes, it is considered that the abrupt rise of groundwater level or pore water pressure is a possible factor that initiate landslide movement during earthquakes.

Keywords: Earthquake, Landslide, Landslide measurement, Landslide displacement, Groundwater level

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HDS027-P05

Room:Convention Hall

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Self potential measurement at landslide site in Pelabuhan Ratu, Indonesia

Shuhei Yabe^{1*}, Hiroshi Otsubo¹, Shimpei Kon¹, Febty Febriani¹, Peng Han¹, Katsumi Hattori¹, Edy Gaffer², Adrin Tohari², Kohri Sugianti², Boko Nurdiyanto³, Iwan Maulana³, Noor Effendi³, Suhardjono³, Pri Harjadi³

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Recently, rainfall-induced landslides occur frequently. In order to mitigate landslide disasters, understanding of the landslide process and early warning is important. In this study, self-potential approach has been attempted to develop an early warning system for rainfall-induced landslides. The laboratory experiments of landslides under the controlled artificial precipitation and a sandbox have been performed. Their results show the capability to monitor the subsurface water condition using the self-potential method. However, laboratory experiments have limitations in scale and soil layers. Therefore, it is necessary to verify the obtained results by a field (in-situ) experiment.

In July 2009, in order to assess the adequacy of the place as a field site, the electrical resistivity tomography has been performed to estimate the subsurface structure, identify saturation zone, and sliding surface. The result shows that saturation zone and possible sliding surface exist at a depth of 10-20m and 20-25m, respectively.

In August 2010, we installed 39 non-polarizing (Pb-PbCl₂) electrodes at 13 points. At each point, we buried the electrodes at a depth of 1.0m, 2.5m and 4.0m. And in order to check the relationship between self potential and water or soil displacements, 25 tensiometers and a rain-gauge have been installed. Additionally, 3 boreholes have been drilled to verify electrical resistivity tomography results. Two of them is used for clinometer measurements every month to identify slip layers and one of them is for measure of water table. During the installation, impermeable layer around 4 m deep have been also found. This is also a possible slip surface. The continuous data are available after December, 2010 and now the data are going to analyze. The details will be presented in our presentation.

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HDS027-P06

Room:Convention Hall

Time:May 24 16:15-18:45

A sandbox experiment for hydrology and electromagnetics coupling

Hiroshi Otsubo^{1*}, Shuhei Yabe¹, Shimpei Kon¹, Febty Febriani¹, Peng Han¹, Katsumi Hattori¹, Edy Gaffer², Adrin Tohari², Khoru Sugianti², Boko Nurdiyanto³, Iwan Setiawan³, Noor Effendi³, Suhardjono³, Pri Harjadi³

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Landslides are one of the most severe natural disasters in the world and there are two types; rainfall induced landslides and landslides triggered by an earthquake. In this study, basic study on early warning system for landslides will be investigated to understand landslide process through hydrological and electromagnetic changes. The final goal of the study is to develop a simple methodology for landslide monitoring/forecasting using self potential method. Conventional methods to monitor landslides are based on geotechnical and hydrological approaches to measure pore pressures and displacement on the surface. In these methods, boreholes are required in general and may disturb the subsurface water system. Making boreholes causes a higher cost for monitoring and it is not so practical for field applications. On the other hand, self potential measurement to measure the surface potential difference using two electrodes is easy to set up and measure continuously.

In this study, the sandbox experiment has been conducted. For the sandbox system, it is possible to control the water table under the soil and it provides us the relationship between hydrological and electromagnetic changes in quantity. We examine various water levels and hydraulic gradients for the investigation. The results show the self potential value seems to be control by the electro-kinetic effect and the water table.

HDS027-P07

Room:Convention Hall

Time:May 24 16:15-18:45

An attempt to construct hazard maps based on slope structures in the Koizu Coast, Shimane Peninsula

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¹Shimane University

Although slope hazard maps have been made all over the world, most of them are not sufficient and not effective for use. Then, the author attempted to construct effective slope hazard maps based on the slope structures and types of slope movements in the Koizu coast, where bedding plane dips almost same trend with that of the slope.

Results of field survey show that slope failures tend to occur along such bedding planes of alternating beds of sandstone and mudstone there. Although the rock slope has roughly 'slipping structure', dip angle of the slope is gentler than that of bedding plane in most portions, and therefore they are relative stable. However, dip angle is steeper than that of bedding planes along outer rim of cave portions due to gully erosion or wave erosion. Probably, unstable condition propagates from such portions to whole slopes.

Based on the mechanism mentioned above, that is slope failure occur along bedding planes, it may possible to evaluate the degree of the instability in each points by analyzing geometrical relationship between slope shape and bedding plane. Analyses were made by using Hoek and Bray method and geological and topographic data, which were obtained from strike map of bedding planes and 5m mesh DEM.

The slope hazard map constructed here shows that unstable regions tend to appear along the portions influenced by gully erosions or wave erosions, and the unstable zone will expand along whole slopes from such portions in this area.

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HDS027-P08

Room:Convention Hall

Time:May 24 16:15-18:45

Origin and age of LiDAR-detected scarplets on the mountain slope: a case study around Iyano in Neo valley, central Japan

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Recent airborne LiDAR survey has detected many scarplets in the mountains around the northern tip of the active Neodani fault, central Japan, which is one of the faults that were ruptured during the 1891 Nobi earthquake. To examine origin and formation age of some of these small scarps, we conducted LiDAR-data analysis, geomorphologic and geologic mapping, and pit excavation around Iyano in Nogo valley. Our results show that the scarps around Iyano are sagging features associated with gravitational mountain deformation, and can be explained by a model in which toppling and block rotation of reverse-dip slope associated with gravitational subsidence of mountain top creates parallel uphill-facing scarps. In addition, our pit excavation in a linear depression along one of the scarps reveals that the scarp was formed before 15th century. Furthermore, the scarp is likely to have grown at least once after its formation. Further study of similar scarplets elsewhere may clarify the relationship between formation and growth of those scarps and surface-faulting history of the Nobi active fault system, including the Neodani fault.

Keywords: Neodani fault, mountain slope, airborne LiDAR, scarplets, Nobi Earthquake, sagging

HDS027-P09

Room:Convention Hall

Time:May 24 16:15-18:45

Landslide inventory mapping in the Lower Nepal Himalayas and its implication for landslide susceptibility mapping

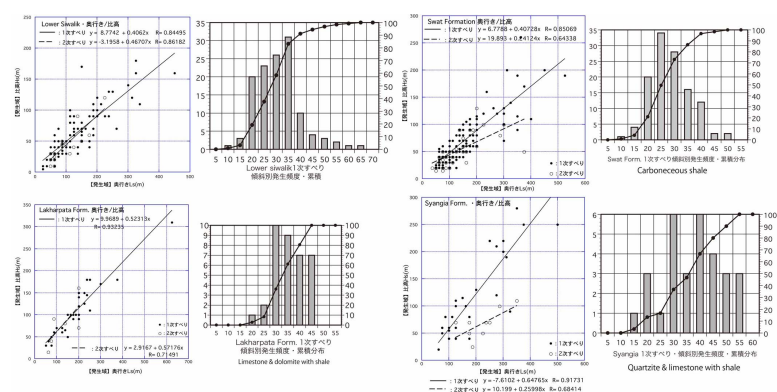
HIROSHI YAGI^{1*}, Hiroshi, P. Sato²

¹Yamagata University, ²Geospatial Information Authority, Japan

Inventory mapping of landslides in the central western parts of Lower Himalayas in Nepal was implemented, using aerial photographs in scale of 1/50000. A study area covers from longitude 83 east to 84.025 degree east and from latitude 27.5 degree north to 28.375 degree north. This area also covers Siwalik Hills, Mahabharat Ranges and Lower Himalayas where active faults are distributed and of which altitude is ranging 100 to 2800m asl. The active faults such as MCT and MBT continue along the base of the foothill of Nepal and Indian Himalayas. The inventory map is superimposed with topographic map generated from GDEM, geological map in scale of 1/200,000 issued from Geological Survey of Nepal and active fault map located on topological maps in scale of 1/50,000. Author measures geomorphological characteristics of landslides of which total number is 512 in and Tansen area, such as width, relative heights and gradients of source area of landslides for each geological type, to clarify the geomorphological and geological conditions that are prone to cause landslides.

Mean slope gradient of landslide source area is different by each geological type. And the critical gradient at which the number of landslide abruptly increases varies by each geological type (Fig.1). It means that lithological property of each rock affects the degree of vulnerability for landslide. Gradients of the secondary landslides decrease compared with those of the primary ones, due to advanced fracture of rock masses. The most hazardous rocks in this region are Lower Siwalik Formation of unconsolidated mudstone or Swat Formation of carbonaceous shale that easily slide at lowest angle. Those slope angles of source areas are less than 20 degree. However, limestone or dolomite of which critical slope angle is as high as ca 30 degree, indicate high rigidity and resistance for landslide.

Earthquakes that occur along those active faults will affect stability of Himalayan mountain slopes. Authors try to prepare the susceptibility map on earthquake-induced landslides, nsidering those causative factors of landslides.



Keywords: landslide inventory map, Lower Nepal Himalaya, geomorphologic feature of landslide, critical slope gradient, landslide susceptibility map, active fault

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HDS027-P10

Room:Convention Hall

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Relationship between rock weathering and geological structures in the Dumre Besei landslide, Lesser Himalaya Nepal

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Dumre Besi landslide is one of the most active landslides along Mugling Narayanghat road section of Nepal Himalaya that was initiated during the monsoon of 2003. The external trigger of this landslide is heavy rainfall, however geological structures and rock weathering have played the key role in the formation of this landslide. The main lithology of the landslide zone is thinly laminated light grey siltstone, grey sandstone (quartzite), bluish grey to white phyllite, black carbonaceous shell, and dolomite. A thrust fault passes through the center of the landslide, which has created a thick deposit of loose and weathered rock material and has developed very thick shattered zone, where weathering is very intense. The rocks in the landslide zone are divided into 5 zones according to the severity of weathering as none, slight, moderate, severe and complete based on field and laboratory analysis.

Laboratory analysis suggested that the chemically weathered rocks are significantly rich in clay minerals. Formation mechanism of clay minerals was analyzed by various techniques as XRD, XRF and thin section analysis and it was found that most of the clay minerals are formed by weathering of rocks. The main clay minerals thus formed are chlorite, smectite and vermiculite. These clay minerals reduce the rock strength and also smectite has a swelling property when water is added into it. The weathering and thrusting has created a thick zone of loose material that is rich in clay minerals, which flows as the debris in every monsoon season. Also, the slope angle, topography, rainfall and ground water are responsible for the formation of this landslide.

Keywords: Landslide, Himalaya

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HDS027-P11

Room:Convention Hall

Time:May 24 16:15-18:45

Features of Slope Disasters on Roads by the Heavy Rainfall in Chugoku and Northern Kyushu Area in July 2009

Ken-ichi Asai^{1*}, Hiroyuki Hayashi², Yasuhito Sasaki³

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We collected 90 cases of the slope disasters on national and prefectural roads by the Heavy Rainfall in Chugoku and Northern Kyushu Area in July 2009, and examined the characteristics of these slope disasters.

More than 50% of disasters are surface collapse at cut slope, about 20% are the collapse of the embankment and road shoulder. On the other hand, the natural slope surface failure is about 15% less. And most of debris flows occurred locally around Hofu city.

The geology of the disaster area is mainly consisted of granites, schist, and Tertiary sedimentary rocks, and both of these are remarkably weathered. Many cases of the collapse occurred in "non-Valley" slope such as the cut slope on the ridge, and the relatively few cases occurred in the valley. Some cases of the collapse of embankment and road shoulder is influenced by the concentration of the water flowing on the road.

Slope disasters occurred not only in the heavy rainfall area, but only in a few rainfall area. Many disasters are caused by weathering over time of cut slope, surface water on the road, watershed change by land development around the road, and cut in small valley by the new or widening road. These causes are not focused on previous patrols and inspections. And also there are many cases that a small valley remains still above the cut slope and no countermeasures against soil flow.

These disasters reveal the problem that the present countermeasures have been mainly protecting slopes but have not been specifically cut off sources of surface water. Disaster risk and road maintainance costs can reduce in the future, implementing measures against surface water, for example, to disperse surface water.

Keywords: slope, disaster, heavy rainfall

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HDS027-P12

Room:Convention Hall

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Features of Slope Disasters on Roads by the Heavy Rainfall in Amami Area in October 2010

Hiroyuki Hayashi^{1*}, Ken-ichi Asai¹, Yasuhito Sasaki¹

¹Public Works Research Institute

We collected about 60 cases of slope disasters of roads in Amami area 2010, and examined the features of disasters.

About 80% of road slope disasters have occurred in cut slope, about 60% are surface slope collapse, and 20% are the large-scale collapse from the natural slope above cut slope. The number of disasters is less than that in usual rainfall disaster, but the size of each disaster tends to slightly larger.

Basement rock in this area is mainly consisted of shale and sandstone of the Shimanto Belt. Many places of the slope disasters have deeply weathered and become red soils. Cut slope collapse is in the shallow surface, but the collapse at the ridge cut occurred deep.

There are only few cases of debris flow. Collapse of the embankment and road shoulder is about 10 percent. The main cause of the collapse of shoulder is concentration of the large amount of water flowing on the road surface.

Keywords: slope, disaster, heavy-rainfall

HDS027-P13

Room:Convention Hall

Time:May 24 16:15-18:45

Study on the feature of the landslide using GPS monitoring and LiDAR DEM

Tomoyuki Takami^{1*}, Sakae Mukoyama¹

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The landslide disaster occurred at Shimekake district in Yamagata Prefecture on the snow melting period in 2009. We studied on the form feature and the movement style of the landslide from distribution of the ground surface cracks, the continuous GPS observation, and the comparison analysis using LiDAR DEM of two times.

This landslide is located in the northwest of Gassan-Volcano. The green tuff, sedimentary rocks, and the dolerite of Neogene are underlying in the surrounding area.

The cracks on the crown of landslide were found in the residential area on February 25. Afterwards, the movement continued until the beginning of July, and many cracks were formed to enclose the landslide area. Afterwards, the movement has decreased since July 8.

The subsidence zone was caused on the head of landslide in the direction of E-W. On the western side of the movement area, cracks were caused in parallel in the direction of the southwest. On the eastern side, cracks with bump were formed in parallel. In the part of southwest, the rice field upheaved and tilted due to strike-slip cracks with bump.

Only the GPS observation followed to the rapid and large movement. The maximum of the amount of the accumulation displacement reaches 4.2-6.2m (15cm /day) in the beginning of July. Main body of this landslide moved toward south, and on the toe of landslide, moving direction changed to eastward.

The displacement vector was analyzed with the method of Digital Geomorphic Image Matching Analysis. The center part of the movement block moved toward south about 5m for five years. The place of changing displacement value is corresponding to the part where cracks were remarkable on the ground surface.

This landslide is rock glide type that platy body slide down on the plane. The landslide movement was strongly controlled with geological structure of Neogene strata. Landslides with large movement like this landslide are well observed with GPS and LiDAR.

Keywords: GPS, LiDAR, landslide, disaster, snow melt period

HDS027-P14

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Experimental Study on the Damaging Mechanism of Cable by Submarine Landslides

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1.Introduction

Submarine communication cables are frequently broken by submarine landslides and turbidity currents. When the cable was cut, the economic loss is vast for cable restoration and the stop of information transmission. However, there are considerable points are not clear because the submarine cable breaking occurred under the surface of water. For the prevention and mitigation of the sea area disaster around Japan, the study of submarine landslides is necessary.

The aim of this study is to quantitatively evaluate and analyze the impact forces against the submarine cable. From the view-point of lifeline disaster prevention, the estimate of impact forces to cable by submarine landslides is very important to contribute to the marine development and use in the future.

2. An experiment method and condition

An experimental apparatus to study submarine landslide was developed and used in this study. This apparatus is a cylindrical water tank of 1.9m in height, 1.8m in diameter, and 0.4m in width. Cylinder bottom has shear stress sensor, pore water pressure sensor, and normal stress sensor. By putting the mixture of water and soil into this apparatus, and making it rotate, it is going to reproduce the submarine landslide. It can be rotated at the speed from 0.013m/s to 0.78m/s.

In addition, the impact forces to the cable are able to be measured by setting up the cable model that puts the strain gauge in the apparatus while the submarine landslide is moving. The cable model is a pipe made of the vinyl chloride of 22mm in the diameter. As for the real submarine cable in the spot, the transformation to the cable extension direction is not forgiven so that it is considered to be the infinite length. Therefore, both ends of the cable model are fixed perfectly in the submarine landslide apparatus.

Experiments were carried out to clarify the three influences: (1) Influence by the velocity of submarine landslide; (2) Influence by the volume of submarine landslide; (3) Influence by the setting height of the cable.

Silica sand No.7 was used for those experiments. This silica sand has following features. Soil particle density = 2.63g/cm³, Maximum density = 1.566g/cm³, Minimum density = 1.026g/cm³, Maximum void ratio = 1.563, Minimum void ratio = 0.679, D₅₀ = 0.1mm, D₃₀ = 0.079mm, D₁₀ = 0.056mm, uniformity coefficient = 1.82, coefficient of curvature = 1.09.

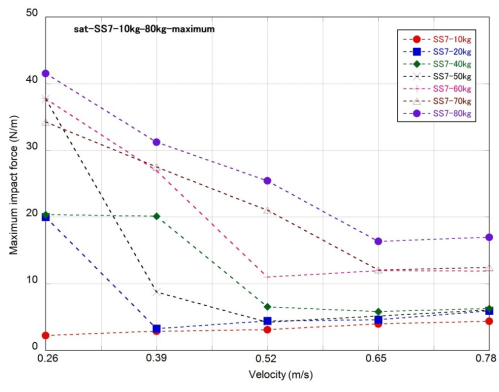
3. Consequence and consideration of experiments

First, experiments that 10kg~80kg of saturated silica sand No.7 rotated by 0.26m/s~0.78m/s were conducted.

The figure shows the relation between maximum impact forces (N/m) and landslide velocity (m/s). As a result of those experiments, the impact forces to the cable model became greater when landslide velocity became slower. The impact forces decreased to a critical velocity and then increased with landslide velocity. In addition, the critical velocity became faster when the volume of landslide became larger. Here are some reasons to consider: (1) Non-turbid Soil mass movement strike against the cable model; (2) As landslide velocity became fast, soil mass movement was became current of low density. In other words, soil mass movement shows aspect of submarine landslide when slow velocity. However, soil mass movement shows aspect of turbidity current when fast velocity.

The impact forces to the cable model became larger with the increase of the volume of the landslide, and the impacting time became longer.

However, clear tendency wasn't found from the difference of the setting height of the cable model. More experiments by various setting height of cable is necessary in future work.



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Characteristics of landslide hazard related to knick line distribution and premonitory phenomena of landslide occurrence

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Characteristics of landslide hazard related to knick line distribution and premonitory phenomena of landslide occurrence

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Japanese archipelago situates in plates conjunction of subduction zone, which has many earthquakes and volcanic activities. Mountains also continue to upheaval under the stress space in tectonically active during quaternary. Moreover under the humid condition, rivers erode slopes currently to occur strains and micro failures in slope rock mass and form eroded geomorphology such as knick lines. Slope rock mass become fragile under long term weathering. These geologic, geomorphologic and humid conditions of Japan affect to erosion in low mountainous area in middle basin, and occurrences of mass movement such as landslide and failure.

This paper describes phenomena based on practices, such as the erosion process related to the increased flow after river capture of neighbor basin, the occurrence of rock slope deformation prior to the occurrence of landslides, and the mechanisms of landslides.

Keywords: Knick line, River capture, Mass movement, Loosen rock slope, Landslide

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Pyroclastic flows and lahars at the time of the 2010 eruption of Mount Merapi, Indonesia

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On October 26, 2010, Mount Merapi has resumed eruptive activities after the 4-year dormancy. Pyroclastic flows ran down to the western and southern direction. Especially, pyroclastic flows having occurred in the beginning of November, 2010 were very large and have reached up to 15 km from the summit of the volcano. On the other hand, lahars have also occurred in almost all the rivers in the western and southern directions instead of Gendol River where the extra large pyroclastic flows have occurred. The huge amount of pyroclastic flow deposits remained unsaturated and hot even after one-month has passed since the deposition of the pyroclastic flows. Field measurement shows that some hot-spots which is hotter than 100 degree in Celcius still existed on the deposit. The lahar generation in the Gendol river must occur in near future, but the timing may be later than in other rivers.

Keywords: Mount Merapi, Pyroclastic flow, Lahar

HDS027-P17

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Temporal variations in erosion rate, moisture and water contents near slope surface in a badland in southwestern Taiwan

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We have measured erosion rate and investigated the weathering mechanism of Pliocene-Pleistocene mudstone in the badland of southwest Taiwan. Erosion rate was measured by using erosion pins set on slopes with an average inclination of 45-55 degrees. We found that significant erosion occurred only in wet season from May to September and that the rates were as large as 10 cm/y on average. Such a high rate of erosion is due to the characteristic manner of the weathering of the mudstone, of which uniaxial compressive strength is as high as 10 MPa when dry but becomes a few Mpa when it is wet (Lee, 2007). Physical property measurements and needle-penetration tests performed for the samples drilled from slope surfaces indicated that weathering extended as deep as 10 to 20 cm from a slope surface. The surface layer of mudstone changes its moisture content and hardness according to the precipitation condition. X-ray CT images for the drilled cores show that the density of mudstone has decreased in the surface layer. In-situ monitoring of moisture content and electric resistivity in the slope suggested that salt and water migration occurs in a periodic manner with one or two year cycle in the surface layer of a slope. Salt materials migrate from the depths and are concentrated in the surface part of a slope in dry season and beginning of wet season and are then diluted in wet season. This dilution of interstitial water is assumed to be accompanied by chemical osmosis and following expansion of rocks, of which process may be the essential mechanism of the rapid weathering and erosion of the mudstone in the badland of Taiwan.

Keywords: badland, Pliocene-Pleistocene mudstone, rapid erosion, salinity-moisture variation, monitoring

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Field observation of sediment supply processes in a large landslide using laser profilers

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Large-scale landslides continuously supply sediment into rivers after their initial formation by increasing in their size and the denudation of exposed bed rock. We quantitatively examined characteristics of sediment supply processes in the Aka-Kuzure, a large landslide in central Japan, based on the laser-scanning data in 2003, 2007 (Airborn LiDAR) and 2010 (Terrestrial Laser Scanning). By comparing topographic data in three periods, three types of sediment supply processes were found in Aka-Kuzure: deeper landslides (> 10 m in depth), linear erosion (erosion rate of about 1 m yr^{-1}), and sheet erosion (erosion rate of about 0.2 m yr^{-1}). Deeper landslides were found above knick lines, whereas linear erosion occurred around steep slopes in the stepped terrains parallel to the bedding planes. These results indicate that the type of sediment supply process in the Aka-Kuzure is affected by local topography and geology.

Keywords: large landslide, Aka-Kuzure, laser profiler, sediment supply