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ABSTRACT BOOK

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High Level Forum

UNESCO's contribution to geo-hazards disaster risk reduction

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Abstract

UNESCO operates at the interface between natural and social sciences, education, culture and communication playing a vital role in constructing a global culture of resilient communities. UNESCO assists countries to build their capacities in managing disaster and climate risk and with their ability to cope with disasters. The Organization provides a forum for governments to work together and it provides essential scientific and practical advice in disaster risk reduction. UNESCO's programmes in relation to the International Strategy for Disaster Reduction (ISDR) cut across all of its areas of competence (education, natural and social sciences, culture and communication). Working alone or in collaboration with both UN Agencies and other scientific entities, UNESCO has been a catalyst for international, inter-disciplinary cooperation in many aspects of disaster risk reduction and mitigation. Concerning Geo-hazards disaster risk reduction, UNESCO deals with the promotion of all related geohazards (earthquakes, landslides and volcanoes) in the scientific areas of seismology, seismic engineering and geology. Main projects are on Assessing vulnerability on educational facilities, Mainstreaming disaster risk reduction in UNESCO's designated sites, Earthquake Early Warning System, Safer construction and Community resilience.

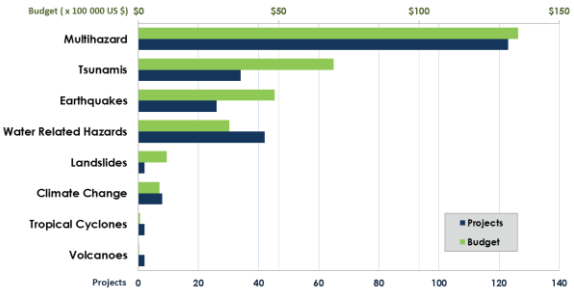

Fig. 1 Distribution of DRR projects by hazards with their budgets for the 2005-2015 period, based on UNESCO reporting system.

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Large ground displacement caused by fault movement and its countermeasure to buried pipeline

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Abstract

A large ground displacement caused by fault movement appeared in wide areas from Kumamoto City to Aso mountain area after the 2016 Kumamoto Earthquake in Japan. Lateral gap of surface ground dominated in Kumamoto City and Mashiki Town and the maximum horizontal displacement was about 2m. On the other hand, vertical gap of surface ground dominated in Aso area. The large ground displacement induced by fault movement also appeared in the 2014 Kamishiro Fault Earthquake in Japan,. A surface faulting with 80 cm difference in level was observed in Hakuba Village. Lifeline facilities such as road and buried pipeline of drinking water supply and sewerage were severely damaged by the surface faulting.

It was reported that there were damages of buried pipeline such as compression deformation and lateral deformation because of surface faulting in the Chichi Earthquake in Taiwan and the Kocaeli Earthquake in Turkey in 1999. There are cases that pipeline sometimes need to be installed across a fault even if it is already recognized there. Therefore, pipeline shall have the structure enough to absorb such fault displacement.

Earthquake Resistant Ductile Iron Pipe (ERDIP) can absorb the ground displacement with its joint expansion/contract and deflection mechanism in the earthquakes. In the past 40 years, the ERDIP has experienced a lot of big earthquakes with Japanese seismic intensity scale 6 and more, and faced severe liquefaction such as the 1995 Kobe Earthquake and the 2011 Tohoku Earthquake in Japan. However, the number of studies on performance of pipe and its safety at fault crossing is not so many and limited to small size pipeline.

This study focuses on larger diameter pipe which may cause big damage to water system by earthquake and quantitatively measure how much of fault displacement the normal pipeline can absorb. The countermeasure against such large displacement caused by fault movement was also studied.

The following conclusions may be drawn based on the present study.

1) DN1500 US-type ERDIP pipeline can absorb 1.6-meter gap of surface faulting by the joint expansion/contraction and deflection. The stress generated on pipeline after fault movement is within elastic range.

2) As a countermeasure for 1.6-meter or more gap, it was found that large displacement absorption unit is effective to absorb axial direction local-displacement and can accommodate the 3-meter or more ground displacement.

UNESCO chair on prevention and sustainable management of geo-hydrological hazards

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Abstract

Since June 2016 the DST-UNIFI has been appointed as UNESCO chair on Prevention and sustainable management of geo-hydrological hazards (www.unesco-geohazards.unifi.it).

Geo-hydrological hazards are a major threat to human life, property, cultural heritage and the natural and built environment. They include landslides, floods, debris flows, slope movements, ground subsidence, soil and coastal erosion, sinkholes and other hazards related to the climate changes and to the local hydro-geological conditions. Risk arises from the interplay of these physical processes with social and cultural factors, such as urbanization, emergency planning, risk preparedness and knowledge.

The mission of the Chair is to promote research and development (R&D) for the prevention and management of geo-hydrological hazards, in order to support policies and actions of risk reduction.

In particular, the Chair aims at the implementation of the Sendai Partnership 2015-2025, launched at the World Conference on Disaster Risk Reduction (WCDRR) in Sendai by the International Strategy for Disaster Reduction (ISDR) and by the International Consortium on Landslides (ICL), for global promotion of understanding and reducing landslide disaster risk, which was also signed by UNESCO and the Italian Government, among other partners and UN organizations. Applied research for a Safer Society is the main keyword of the Chair.

The specific objectives of the Chair are:

1. to promote the development of innovative technologies for the prevention and mitigation of geo-hydrological hazards and to develop models for the forecasting of the hazards in the framework of climate change scenarios;
2. to develop tools and procedures for supporting risk reduction policies and emergency management for the safety of the human life;
3. to promote the protection of cultural heritage threatened by geo-hydrological hazards;
4. to promote research at international level by offering scientific facilities to post graduated students and visiting researchers.

Several types of activities will be carried out in the framework on the Chair, such as: postgraduate teaching programme, short-term training, research, visiting professorship, scholarships, and institutional development.

The target beneficiaries will be students, professionals, academics and, governmental organizations.

Raised-bed rivers in Japan –relics of the historical interaction between floods, landslides, and socioeconomic system-

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Abstract

Raised bed river should be a typical artificial landforms which became necessary the environmental changes in the upstream region of rivers. A famous painting in 19th century shows that travelers could go across the raised-bed river (the Kusatsu River) by walking because of very little water flow. The roof of houses was painted behind travelers at almost same level. It means the ground level of village was so lower than the level of the river bed. These rivers of higher river bed (floor) than the ground level of surroundings are called "Tenjo-gawa", it means "the river on the roof" in Japan.

Like this scenery between river and villages, the Tenjo-gawa, are common in western part of Japan because that the Tenjo-gawa was formed artificially during historical urban developments. The western part of Japan, the Kinki district, was the region having highest density of population before the construction of Edo (Tokyo). When the river channel was artificially fixed, the river bed started to be rising by the overloaded supply of sediments, and finally the river bed should be so higher than the roof of houses.

It was well known that the rate of river bed rising increased in 17th century, however, the age of the base of the Tenjo-gawa has been unclear. We revealed the river bed rising in the Minami-Yamashiro district started from 14th century by using ^{14}C dating and archaeological survey.

The economic activities of Japanese society increased from 14th century. The development of upstream mountainous area, deforestation and keeping grass field in long term period, led to increasing landslides and topsoil erosion in the mountainous slope, so that the bare mountains were common scenery around the advanced developed region in Japan during the ages of raised bed rivers from the 14th to the 19th century. The backgrounds of the beginning of these exhaustive developments in mountainous slope surrounding of urban region are reflected in the social changes going on the 14th century. Social confusion continues to demise of ancient order forced to take the regional social and economic integration and generated the new integrated villages that they interested to increasing food production by cultivation needed to large quantity of grass supplied from grass (bare) mountains. The classic landscape of raised bed rivers in Japan which started in the mediaeval ages shows the history of interaction between environmental changes and ancient society. It achieved the increase of total population, however, serious flood disasters caused by the river bed rising were initiated. The Tenjo-gawa, raised-bed river, is a historical legend showing the interaction between artificial environmental changes and society.

Innovative technologies for landslide monitoring and early warning

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Abstract

The work focuses on the application of innovative monitoring techniques to estimate the deformational evolution of the landslide masses and the successive operative implementation of Early Warning Systems (EWS). In particular it deals with the optimization and validation of the operational protocols for technical and scientific support in areas at risk and on the definition of rapid procedures for assessing landslide risk and proper managing of each emergency situations. This is achieved by the synergistic use of rapid mobile units for localized survey based on terrestrial, marine and airborne sensors. The technologies are: Ground-Based Radar (GB-InSAR), Wireless Sensor Networks (WSN), Laser Scanner (LIDAR and TLS), Infrared Thermography (IRT), Robotic Total Station (TPS), Multi-Beam Eco Sounder. The supplementary use of marine and airborne sensors will be concretely achievable with the same accuracy because the drone structure (SATURN) and the ROV vehicle (Remotely operated underwater vehicle: NEMO), recently patented by the DST-UNIFI, are capable of mounting integrative technologies that meet the required demands.

The integrated use of different technologies was adopted and put into operation in some Italian sites to estimate the deformational evolution of instable slopes and consequently to obtain useful information for developing efficient strategies that can operatively implement the existing Early Warning Systems (EWS) or create new ones. In particular an integrated system (GB-InSAR, TLS) was installed to monitor an anthropized river bank (fully remodeled by interventions in the 19th century) in the historical center of Firenze, declared World Heritage by UNESCO. The GB-InSAR was installed just after its first movement (May 25, 2016) to guarantee safety of population, historical buildings and workers in the first technical interventions and to monitor any possible further displacements in the wall embankment through a rapid data acquisition (maximum 5 minutes each time). After this a comprehensive early warning system in the whole involved area (directly and indirectly) based on levels of criticalities, thresholds of alert and warning bulletins for the optimal security management. This complete and synergic monitoring system was optimized in the entire course of restoration works according to the different needs of the construction site or the landslides investigations.

Soil-water interaction modeling based on discontinuous deformation analysis method

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Abstract

Soil-Water Characteristic Curve (SWCC), the function of soil moisture content with the soil matric suction, is an essential parameter to present the property of unsaturated soils. Matric suction is the actions of the capillary force among soil particles. In this paper, a soil specimen is simplified as a series of elastic polyhedral element aggregates, while the capillary force of the water are applied among the elements to modeling the unsaturated soil. According to Kalvin's equation, a soil in equilibrium state should has the same matric suction at each position, which means the soil should has the same curvature of the capillary menisci at all the water action points among the soil particles. The matric suction can be calculated by Yong-Laplace equation with the curvature radius. Based on these concepts, Discontinuous Deformation Analysis (DDA) method are used to simulate the soil water interaction on microscopic scale.

A computer program has been modified with the originally DDA code which was designed by Prof. Genhua-Shi. With the new program, the matric suction among soil particles can be precisely calculated as giving a soil microstructural model and the moister content, consequently, the SWCC can obtained with a sequence of moisture contents and calculated matric suctions . Furthermore, an odometer test with the soil microscopic model at giving moister contents can also be simulated and the *e-lgp* curve can be obtained. The results can well illustrate the unsaturated soil behaviors intrinsically. Because of limitation of computation capability, the program at present can only simulate the ideal model with small quantities of soil particle elements, further research are intending to simulate the real unsaturated soil with large quantities of elements.

Total quality management in landslide disaster risk reduction in Indonesia

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Abstract

Due to the dynamic geological conditions combined with high rain precipitation and uncontrolled landuse changing, more than 50% of Indonesian region is prone for landslides. In fact, socio-economical-cultural conditions problems have been identified as the underlying risk drivers. Those include problems of poor community preparedness and awareness due to limited access to the information for landslide disaster risk reduction and limited capacity of the local community, local government, university and also non government organizations. Unfortunately, technology for disaster mitigation and EWS not yet quite easy to be operated and maintained by the local people.

This paper highlights the importance of Total Quality Management (TQM) on Landslide Disaster Risk Reduction, by integrating both technical and social aspects. The technical aspects include the geology-landslide-landuse mapping to identify the zone and level of hazard and risk, whilst the social aspect comprises social and institutional mapping to identify the potential social risks and challenges. All of those will be the the success drivers for developing the appropriate design of DRR program. Stronger linkage with policy makers must be developed properly, to ensure them about the importance of landslide DRR. As the results, their awareness and commitment to apply the research-based recommendation for reducing the risk of landslides into policy and practice can be raised. One of the most important recommendation is the integration of hazard and risk maps into regional or landuse planning, which must be supported by stronger law-enforcement. To ensure the success of this TQM, research-based innovation for developing appropriate technology in DRR, public education, and also community-based landslide monitoring and early warning system need to be performed properly.

Acknowledgments

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SPH-based liquefaction analysis of detached house foundation

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Abstract

A large settlement and tilting of detached house have been often observed due to ground liquefaction. On March 11, 2011, a magnitude Mw 9.0 earthquake attacked Urayasu city in Chiba Prefecture, Japan. Extensive damages were inflicted to lifelines and detached houses due to widespread liquefaction and lateral spreading in reclaimed areas. In order to reduce the damage of the detached house, we have to predict the intensity of deformation precisely.

We are now able to predict the deformation due to liquefaction by using 2D or 3D dynamic effective stress analysis with complex constitutive models. However, limited engineers can use these programs. Furthermore standard penetration tests as well as laboratory tests are necessary to determine constitutive model parameters and the cost of its process is expensive for detached house owners.

In this study, firstly the authors proposed a new numerical scheme based on the Lagrangian mesh free particle method (SPH) with a very simple constitutive model. This constitutive model parameter is obtained by a low cost simplified investigation using: Cone Penetration Test (CPT) and Swedish Weight Sounding (SWS). Secondary we tried to reproduce the localized deformation of the ground by using the proposed SPH scheme. Furthermore a detached house severely damaged during the 2011 off the Pacific coast of Tohoku Earthquake was also targeted for the verification of the performance of the proposed SPH scheme.

As a result, in this study, the following conclusions were obtained.

1. Constitutive model parameters can be determined from SWS, CPT, soil sampling, and groundwater level survey.
2. Proposed SPH scheme is able to approximately reproduce the severe damage of the detached house during the 2011 off the Pacific coast of Tohoku Earthquake.
3. To predict an uneven settlement of detached house precisely, we should investigate ground condition. Therefore, we have to carry out site investigations.
4. Damage level of detached house during liquefaction depends on the stiffness of non-liquefaction layer.

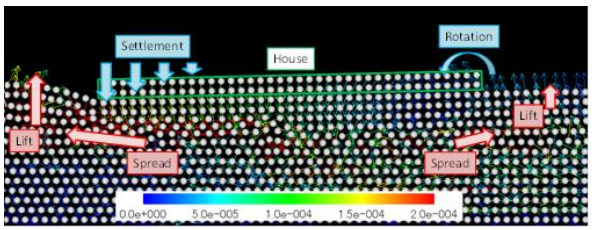

Fig.1 Velocity vector around detached house.

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Keynote Lecture

An approach of landslide risk assessment in Japan by considering global climate change

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Abstract

Landslide is one kind of geo-hazards and often causes very serious disasters in the world. The major triggered factors of landslides are heavy rainfall or/and strong earthquake. In Japan, most of landslides occurred in the period of a Typhoon or localized heavy rain. Thus, heavy rainfall should be considered in landslide risk analysis. On the hand, climate change induced by global warming is becoming a more and more concerned problem in the world. As a result, it is expected that the number of heavy rainfall events will increase with the effect of global warming and then landslide risk will increase too. Therefore, the risk assessment of landslides considering climate change is important and necessary for both disaster mitigation and global warming risk assessment. However, how to assess landslide risk in a wide area like the whole Japanese land, has not yet been developed. In this paper, we present an approach of landslide risk assessment in a wide area by considering climate change, which is based the Geographic Information System (GIS). Firstly, an approach of frequency analysis of landslide is presented based on ArcGIS platform. Secondly, an approach of consequence analysis of landslide is presented by considering private property, business property, public property and value of agricultural products together with, economical loss from restoration cost. Thirdly, a landslide hazard map and a landslide risk map over the whole Japanese land are made. Thirdly, the landslide risk is assessed 100 years late based on the increasing tendency of heavy rain due to climate change. Finally, a numerical simulation tool is developed for high accurate predication of landslide for some high risk areas.

Acknowledgments

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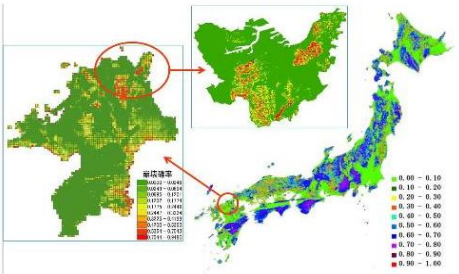

Fig. 1 Landslide hazard maps with different scales

Dynamic reliability analysis of slopes

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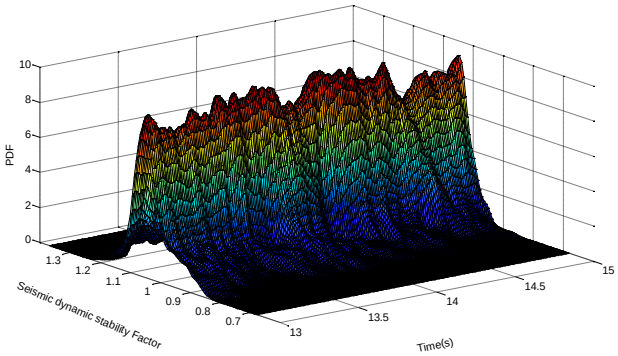
Abstract

The seismic dynamic stability of slopes are mainly controlled by the seismic ground motion and mechanical properties of rock and soil mass. The stochastic in intensity and frequency is the intrinsic characteristic of seismic ground motion. However, due to the coupling of randomness and nonlinearity of the stochastic dynamic system of slopes, most of the existing researches cannot fully grasp the essence of the seismic response of slopes. Therefore, we attempt to grasp the seismic response and dynamic stability of slopes based on a random vibration method

The paper establishes a category of fully non-stationary stochastic seismic ground motion model based on the spectral representation method and the concept of random function. And a series of seismic acceleration time history samples with assigned probabilities in the same set system are generated.

Closely combine with the stochastic seismic ground motion model, the stochastic seismic dynamic responses of the slope at the level of probability density functions (PDFs) are obtained in light of the probability density evolution method. And then, the seismic dynamic stability of the slope is evaluated from the point view of dynamic reliability.



Acknowledgments

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EO (Earth Observation) data and technology to detect, map, monitor and forecast ground deformations

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Abstract

Research activities were dedicated to deepen the use of satellite remote sensing radar data for the identification (detection and mapping), analysis and monitoring of gravitational slope deformations in order to define proper risk scenarios and to support the management of their evolutionary phases. The activities are also aimed at improving the satellite surveillance system based on all the EO data (radar, multi- and hyperspectral) already available from several satellites (ERS, ENVISAT, RADARSAT, COSMO-SkyMed). Such integrated system will be designed for identifying, rapid mapping, monitoring and analysis of risk scenarios. Under the European program, called Copernicus, the recent launch of the SENTINEL-1 satellite (able to provide information in continuity with those from ERS and ENVISAT) offers new opportunities for monitoring the Earth's surface and for the evaluation of ground movements. Such activities are possible at different scales of investigation and at different geological contexts using advanced processing techniques and interpretation of interferometric data derived from satellite images acquired by old and new systems. In order to optimize this satellite surveillance procedure during forecast, emergency and post-emergency cycles, the performed activities were concentrated on:

- Monitoring and analysis activities supporting the instability evaluation of slopes affected by underway gravitational movement through the application of satellite radar interferometric techniques and their integration with ground-based data.
- Statistical analysis of slope displacements for the detection of the deformation trends, through the study of temporal series of the interferometric SAR data for early warning purposes, prediction of events and temporal interpretation (as accurate as possible) of localized landslides. In particular the temporal series of deformation were statistically analyzed in order to: i) identify anomalous deformation trend; ii) understand the landslides evolution for forecasting purposes; iii) set up motion thresholds useful for alerting purposes.

Characteristics and failure mechanism of the deadly June 24th 2017 Xinmo landslide, Maoxian, Sichuan, China.

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Abstract

At 5:38 am on the 24th June, 2017, a catastrophic rock avalanche destroyed the whole village of Xinmo in Maoxian County, Sichuan Province, China. About 4.3 million m^3 of rock detached from the crest of the mountain, gained momentum along a steep hillslope, entrained a large amount of pre-existing deposits and hit the village at a velocity of 250 km/h (Fig.1). The impact produced a seismic shaking of ML = 2.3 magnitude. The sliding mass dammed the Songping gully with an accumulation body of 13 million m3. The avalanche buried 64 houses; 10 people were killed and 73 were reported missing. The event raised great concerns both in China and worldwide. Extensive field investigation, satellite remote sensing, UAV aerial photography and seismic analysis allowed to identify the main kinematic features, the dynamic process and the triggering mechanism (Fig.2). With the aid of ground-based synthetic aperture radar monitoring, the hazard deriving from potential further instabilities in the source area has been assessed. The preliminary results suggest that the landslide was triggered by the failure of a rock mass which had been already weakened by the Ms 7.5 Diexi earthquake in 1933. Several major earthquakes since then, and the long-term effect of gravity and rainfall, contributed to the mass failure. The high elevation, slope angle and vegetation cover in the source area hinder geological field investigation and make hazard assessment difficult. Nonetheless, monitoring and prevention of similar collapses in mountainous areas must be carried out to protect human lives and infrastructures. To this aim, the integrated use of modern high-precision observation technologies is strongly encouraged.

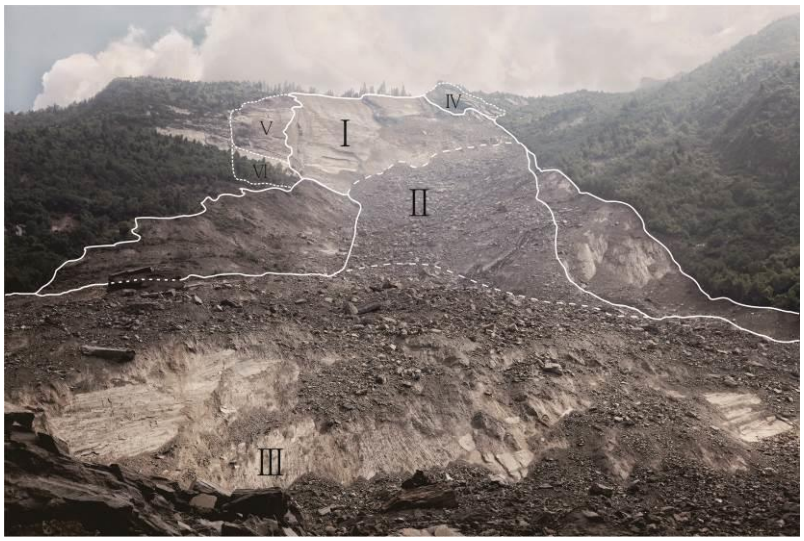

Fig.1 An overview photo of the Xinmo landslide showing the source (I), transportation (II) and deposition areas (III)

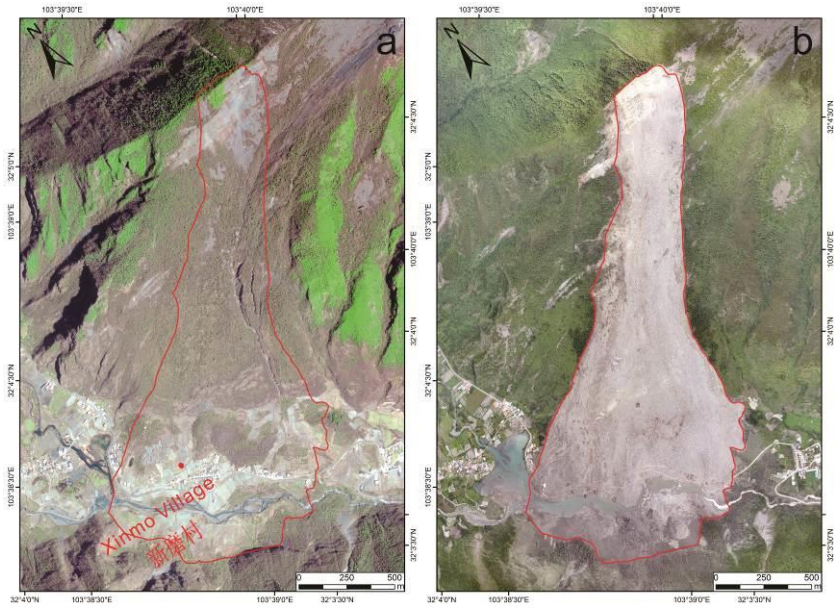

Fig.2 Pre-sliding image from Chinese Gaofen-2 taken on April 8th, 2017 (a) and Post-sliding image taken by UAV on June 26th, 2017 (b)

Acknowledgments

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A toppling failure of the right bank slope in a hydropower station, SW China

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Abstract

Influenced by Qinghai-Tibet Plateau uplift and rivers incision, landform undulates largely and rock masses quality is quite poor in the west and southwest China. The high cut slopes from human activities such as hydropower station construction are incident to get unstable under some conditions. Among these, a toppling slope failure occurred in Feb. 2015 in a hydropower station in southwest China is very representive case. The failure process was recorded by video completely, which clearly disclose the failure induced by a tardy support after an excavation. Some engineering geological approaches are used to analyze the mechanism, such as stereographic projection and qualitative analysis. It is indicated that the factors resulting in slope instability can be divided into internal factors and external factors. The former includes the high and steep terrain, toppling deformation, low rock mass strength and fault existence. The external factors i.e. slope excavation and seepage after snow accelerate slope toppling failure. The progressive failure was also detailed based on the video and a comprehensive numerical simulation.

Key words: slope stability, toppling deformation, failure mechanism, failure characteristics

Importance of spectral acceleration in evaluating cyclic failure on soft clays – an experience from 2015 Gorkha earthquake

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Abstract

The 2005 Gorkha earthquake killed close to 9,000 people and left over 22,000 people injured. The overall damage caused an economic loss of over $ 10B, which is close to 50% of the Nepalese GDP. In addition to many buildings, collapsed throughout the country, over 15,000 seismically triggered landslides were recorded (Tiwari et al., 2015). Although ground motion data was available for one station, KATNAP, immediately after the earthquake (GEER, 2015), a few more data were released within a year after the Gorkha earthquake.

Immediately after the earthquake, road alignment along Araniko highway at Lokanthali, which was built in gentle slope, showed distress, misalignment and sliding with clearly visible scarps, demonstrating over a meter of displacement towards the creek below the road. The distress was characterized by kilometer long continuous cracks. This crack was first thought to be a part of ground rupture surface; this hypothesis was rejected within a few days of the earthquake. GEER (2015), the first one to characterize the soil in this area, performed trenching and extensive field mapping. The report described it to be either liquefaction induced ground failure, or cyclic compression, or cyclic clay failure. The authors performed field investigations including topographic mapping, boring, Swedish cone penetration, and vane shear tests. Moreover, soil samples were collected from 1-4 m depth Index properties, static shear strength, and dynamic properties of the collected soil samples were measured. Deformations of the slope were calculated using FLAC by inputting the soil test data for all of the recorded ground motion data, specifically using velocities obtained by deconvoluting the ground motion data. Post-earthquake undraiined shear strength of the soil was used for the analysis. The deformation analysis result matches well with the deformation observed in the field. This presentation includes result of field investigation, laboratory soil test, and numerical analysis.

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Deterioration mechanisms of cracked surface crust on salt-laden earthen heritages in northwest China

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Abstract

Earthen architecture with prominent historical, cultural and artistic values is an important composition of World Heritage. However, due to threats from environmental factors, these heritages are degrading more and more and even in great danger. For the Site of Yar City in northwest China, cracked surface crust which is a typical form of surface weathering widely appears on the salt-laden remains in situ. This pathology is considered to be resulted from the strong and concentrated rainfall and the subsequent intense evaporation in summer seasons. To clarify the underlying deterioration mechanisms, series of laboratory tests were conducted on desiccating slurries with different NaCl contents (0%, 2% and 5%) prepared from local soil. Soil water retention curve (SWRC) was measured using three methods including pressure plate method, filter paper method and vapor equilibrium method. Soil shrinkage characteristic curve (SSCC) was obtained by fluid displacement method. Cracking test was conducted to clarify the evolution as well as final morphology of cracking networks resorting to image analysis technique. In addition, MIP test was adopted to investigate microstructure and help interpret macroscale soil behaviors. Results show that with increasing NaCl content, matric suction remained almost the same, while total suction increased significantly because of the induced osmotic suction. During desiccation, all suctions increased gradually as water content decreased. The obtained SSCC was similar regardless of NaCl content, indicating that volumetric shrinkage is mainly controlled by water content (matric suction) variation. Shrinkage curve was composed of three shrinkage zones and the two transition points corresponded to soil water content at air-entry (22%) and shrinkage limit (16%), respectively. Even though total volumetric shrinkage was almost the same, cracking morphology of heritage soil slurries were greatly influenced by NaCl. By characterizing final cracking morphology with four geometric parameters (CIF, segment number, intersection number and total crack length), more extensive drying cracking and highly fragmented soil surface were observed in specimens with lower NaCl contents. In addition, as NaCl content increased, evaporation rate was decreased significantly and the time needed for full desiccation was much longer. Microstructural investigation was consistent with macroscale behaviors that total volume of pores was mainly controlled by water content variation which decreased as water kept evaporating. At comparable water content value, cumulative curve as well as pore size distribution curve were similar for specimens with different NaCl contents.

During desiccation, a unimodal PSD was observed for the tested heritage soil.

Keywords: climate; unsaturated soil; NaCl; cracking; shrinkage; MIP; earthen heritage

Satellite radar observations in support of geo-disaster risk reduction

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Abstract

Earthquakes, together with landslides and other events that they trigger, are a significant proportion of the natural hazards faced by human societies. Earthquakes affect large areas and disrupt normal communications, and represent an increasing risk of human loss and severe economic damage as vulnerable populations grow in areas of seismic hazard. Observations of the seismic cycle not only give insight into the mechanics of a fault, but also play key roles in estimating the likelihood of future earthquakes.

In addition to large earthquakes, landslides can be triggered by other different mechanisms, such as monsoonal rainfall or storms. There are a range of factors that affect landslide motion, including topography, geology, vegetation, precipitation and anthropogenic factors (e.g. man-made roads, deforestation and agricultural terraces). Monitoring landslides is a crucial task to understand their mechanisms, adopt preventive measures and reduce casualties and infrastructure damage.

Interferometric Synthetic Aperture Radar (InSAR) can be used to map changes in the Earth's surface from space, utilizing the phase differences in complex (magnitude and phase) Synthetic Aperture Radar (SAR) images acquired in similar geometric conditions, but at two different epochs, to measure range changes in the radar line of sight to the satellite. This can be done with sub-centimetre precision and metres of horizontal spatial resolution over large regions (e.g. 100 km × 100 km). With its global coverage and all-weather imaging capability, InSAR is revolutionizing our ability to image the Earth's surface and the evolution of its shape over time. Using satellite radar data (SAR) we can pinpoint areas of greatest probable damage, map surface deformation, and determine earthquake and landslide mechanisms, all of which are critical to risk mitigation. This information can be gathered soon after a geo-disaster event, but speed is essential in disaster response and we require new ways to accelerate data processing to provide crucial information to relief teams.

In this presentation, I will use a range of recent events to demonstrate how satellite radar observations can be employed (i) to rapidly respond to large earthquakes, (ii) map and monitor landslides, and (ii) assess future geohazards.

Acknowledgments

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Reactivation of a dormant earthflow documented by field monitoring data

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Abstract

Large, deep-seated earthflows are common in mountainous areas where clay soils or fine-grained weak rocks are dominant. Distinctive features of these landslides are the relatively slow movements and the complex style of activity, in which mass flow is accompanied by basal sliding along localized shear zones. Earthflows are subjected to periodic reactivations separated by long intervals of dormancy. Although the dynamics of earthflows is widely documented in the literature, field data on the reactivation process are almost absent because of the difficulty of catching the critical acceleration phase.

We document the reactivation of a large, dormant earthflow that occurred in February 2014 in the Northern Apennines of Italy. The Montecchi earthflow is located about 50 km to the south of Bologna, on the left side of the Silla Valley. Slopes are mainly constituted by chaotic sedimentary melanges belonging to the Palombini Shale (lower Cretaceous-Cenomanian). The earthflow first reactivated in November 1994, after an apparently unexceptional precipitation of 95 mm over a week. Surface velocities reached the value of few meters per day during the failure, then the landslide slowed down. One month after the reactivation, the velocity reduced to 1.2 mm/day and five months later it was further decreased to 0.1-0.2 mm/day. In the following years, the landslide became dormant with residual movements in the order of few mm/month.

A monitoring system was installed in July 2004 to investigate the slope response to rainfalls and the displacement rates of the landslide during the dormant phase. The monitoring system has been operational for more than 10 years by adapting the number, type, and location of monitoring sensors to the evolving landslide. The monitoring system was operational when, on the 10th of February 2014, the landslide reactivated again. At the time of the failure two monitored sections were operational in the source area (upper section) and in the central part (middle section) of the 1994 earthflow. The upper section essentially consisted of 1 rain gage, 3 surface wire extensometers installed across the main scarp, and 2 instrumented open-standpipe piezometers at 3.6 m depth. In the middle section, 6 instrumented open-standpipe piezometers and 7 pressure sensors directly buried into the ground were installed in the landslide body at depths ranging between 1 and 9 m (about 2 m above the slip surface). Although several sensors were damaged and others were pulled out from the ground during the movement, the reactivation of the earthflow is well documented. The three surface wire extensometers showed a nearly-perfect exponential growth of the displacement rate, that progressively increased from about 1 mm/day one month before the failure to

more than 200 mm/day in the last hours. The initial slide in the crown area then loaded the existing, fully-saturated landslide deposits triggering the downslope propagation of the failure. The pressure sensors buried in the landslide material recorded positive pore pressure excesses due to undrained loading (with hydraulic heads well above the ground surface) generally followed by an abrupt decrease, probably related to mechanical unloading or dilation of the landslide mass. These data indicate that the earthflow was reactivated by a relatively small, drained failure in the source area that propagated downslope as an undrained pulse of mechanical compression and extension.

Hazard mitigation of GLOFs (Glacial Lake Outburst Floods) in the Cordillera Blanca, Peru

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Abstract

Our research on Glacial Lake Outburst Floods (GLOFs) consists from several steps hold in last 10 years and is mainly dedicated to the Cordillera Blanca in Peru. Apart of different case studies dealing with hazardous GLOF events we tried to solve also some more general topics: inventory of lakes in Cordillera Blanca, new methodology for hazard evaluation and establishing of GLOFs database. We also tried to sum all different parameters which influence the GLOFs hazard evaluation. The research on GLOFs is an example of topic which needs a complex approach across geosciences.

Almost forty glacial lakes have been remediated in the Cordillera Blanca since the 1940s by implementing different types of structural measures to prevent (mitigate) glacial lake outburst floods. These are: (1) open cuts; (2) artificial dams; (3) tunnels; and their combinations. First part of the presentation provides overview and description of implemented remedial works. In the second part, the effectiveness of these remedial works is evaluated on the basis of a comparison of the quantified susceptibility of nine selected lakes to outburst floods before and after remediation. Our investigation showed that different types of remedial works have different impacts on the susceptibility of a given lake to outburst floods and are effective for different scenarios (causes and subsequent mechanisms) of outburst floods. Hazard management implications in the framework of risk management and ongoing geoenvironmental change are also considered.

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Invited Lecture 1-4

Stability analysis of MSW landfill slopes based on upper bound limit analysis methods

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Abstract

The stability of the Municipal Solid Waste (MSW) landfill slope has always been problematic and different because of the aging layers and liner system.

Based on the upper bound limit analysis theorem, two-dimensional and three-dimensional failure mechanisms for stability analysis of landfills are proposed. For 3D mechanisms, the one is the combined rotational-translational mechanism, which consists of the curvilinear cone rotational mechanism and the cone translational; and the other failure mechanism is comprised of irregular blocks undergoing translational movements, instead of only vertical slices in the conventional failure mechanism (Fig. 1). In comparison with the results from the shear strength reduction finite element method (SSRFEM), it demonstrates that the validity of upper-bound stability analysis of the slopes with the proposed mechanisms.

Two case histories, i.e. the Kettleman Hills landfill and the Coll Cardús landfill, are analyzed by the limit analysis method. Good agreement with the other methods can be found. Therefore, the 2D and 3D upper bound limit analysis introduced in this paper can be used as a simple evaluation method for the engineering design.

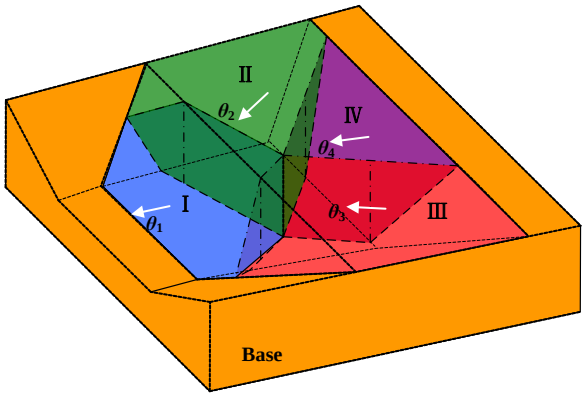

Fig. 1 3D multi-block mechanism for the Kettleman Hills landfill slope

Acknowledgments

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Numerical modeling of debris flows and debris avalanches

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Abstract

Flow-like landslides often propagate inside natural valleys or artificial channels as "debris flows". Alternatively, shallow landslides triggered along open slopes evolve as "debris avalanches". Interplay of mass rheology, bed entrainment and hydromechanical coupling between solid particles and pore water pressures are key issues to be tackled in both the cases.

The presentation deals with the numerical modeling of propagation stage. A "depth integrated" model is used which allows: i) taking into account real detailed topography and ii) using efficient numerical formulation. The used model is "GeoFlow_SPH" (Pastor et al., 2009).

Behaviour of debris avalanches is analyzed with special emphasis on lateral spreading related to flow rheology, topography and pore water pressure. The role of bed entrainment is also investigated for debris flows.

Analyses are carried out for simplified benchmark slopes and relevant case studies of Vesusius district (Campania, Italy) and Ningnan county (Sichuan, China), as reported in Cascini et al. (2014), Cuomo et al. (2014) and Braun et al. (2017). Recent advances on this topic are illustrated.

Acknowledgments

This work was supported by the National Basic Research Program of Italy (Program FARB) through Grant No. ORSA149713.

Fig. 1 Example of case histories analyzed.

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The methods in numerical simulations for slope failure due to rainfall infiltration

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Abstract

The effect of rain falling can be analyzed for the slope failure through experimental and field investigation, and numerical simulations. In a numerical simulation for rainfall-triggered slope failure, the most important is how accurate boundary conditions of infiltration are initialized and preliminary pore water pressure is obtained in a dynamic flowing boundary conditions. To solve these problems, firstly, disadvantages of traditional numerical boundary in infiltration were found through numerical simulation and experimental results. Thus, new boundary conditions of infiltration are present, in which the rainfall infiltration is firstly processed through air units, as a dynamic boundary condition, and then into unsaturated soils. Taking into account these new infiltration conditions, a variety of numerical simulation was carried out in a soil column test for infiltration. It was shown results from simulation coincide with those from experimental tests and field monitoring by others. The proposed method was proved to be effective and accurate for the rainfall-triggered slope failure. Meanwhile, the tensile strength for water as nodes was set to express suction in unsaturated soils, because the relative permeability coefficient and suction are the function of saturation. The changes of saturation in each node can update the relative permeability coefficient and suction in each step of simulation, then the seepage is developed using FISH language in the FLAC software. Moreover, a dynamic flowing boundary condition was proposed to considerate the presence of suction in unsaturated soils. In this condition, the natural rainfall infiltration was simulated through the change of groundwater, and the preliminary pore water was precisely obtained after the development of seepage modules in the FLAC software.

Hazards Induced by the 2008 Wenchuan Earthquake

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Abstract

The 2008 Wenchuan occurred along the Longmen Shan fault system in a mountainous region to the northwest of Chengdu in China. The earthquake resulted in a large number of fatalities and caused significant economic damage. It occurred along a 240 km rupture zone with a maximum estimated slip of 9-12 m.

More than 60,000 landslides were triggered by the earthquake in an area about 850 km^2. A large number of landslide dams occurred during the earthquake, as well as other disasters.

Along the most significant landslides, the Daguangbao rock avalanche was the largest in volume (about $7.4x10^8$ m^3), with a length of 4,200 m, a width of 1,160-3,200 m and a maximum thickness of 690 m.

In the present study numerical models were formulated for this landslide by using the Material Point Method for simulation the interaction of the seismic load in the slope. The results of the processes associated with the failure mechanisms are compared with the post-earthquake profile. Also safety considerations about Daguangbao rock wall stability were analyzed.

Fig. 1 Daguangbao landslide.

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Seismic behaviors of soil slope in permafrost regions using a large-scale shaking table

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Abstract

Large-scale shaking table model tests were carried out to study the dynamic behaviors of slopes and failure mechanism of landslide in permafrost regions. The model slope was constituted of silty clay layer stacked on the ice layer with 8° surface slope. The acceleration, displacement and pore pressure were measured subjected to vertical and horizontal seismic loadings. The horizontal wave has a stronger influence on the failure of the model than vertical wave motion, the natural frequency of vibration in horizontal direction decreased obviously at the failure state. The model slope has three components of different nonlinear mechanical properties, which are soil layer, soil-ice interface and ice layer. The amplification factor of peak ground acceleration is obviously smaller at the soil-ice interface than that of the soil and ice layer. The acceleration responses are nonlinear because of the nonlinear soil properties and degradation of modulus with the increasing horizontal acceleration. Especially, excess pore pressure generation was observed near the soil-ice interface of the slope subjected to the higher input acceleration, which resulted in the decrease of the effective stress. Failure surface appeared to be the soil-ice interface, which was consistent with the field observations of landslides in permafrost regions. Slope failure could be defined based on the massive movement of the slope, characterized by integral sliding pattern along the soil-ice interface without the distinct deformation inside sliding body. The results show that the sliding of slope with soil layer at gentle gradient is mainly triggered by combined action of horizontal seismic wave, existence of soil-ice interface and pore pressure generation in permafrost regions.

Keywords: Qinghai-Tibet Plateau; permafrost; soil layer at gentle gradient; landslide; shaking table; model test

3D numerical modelling of airblast generated by the Wangjiayan rockslide in the 2008 Wenchuan earthquake

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Abstract

In order to quantitatively analyse the intensity and devastating capability of airblast initiated in the extremely rapid travel of rockslide, the Wangjiayan rockslide, occurred in the Wenchuan earthquake, is selected here with the propagation of the sliding mass and airblast evolution being studied firstly using FLUENT by introducing the Voellmy rheological law. And then, based on the data of the airblast pressure acquired in the FLUENT simulation, the collapse behaviours of buildings under the attack of airblast is analysed in detail with the help of LS-DYNA. Through these studies, it is mainly reached that: (1) For the Wangjiayan rockslide, its whole travelling duration is about 12 s with its maximum velocity reaching 36 m/s at t=10 s. (2) Corresponding to the propagation of the sliding mass, the maximum velocity, 28 m/s, of the airblast initiated by the rapid sliding mass also appears at t=10 s with its maximum airblast pressure reaching 594.8 Pa at the leading edge of the sliding mass, which is equivalent to violent storm and can induce a devastating destroy to buildings ahead of it. (3) The buildings in the front row play an important role in the retardation of the propagation of the airtblast with the maximum pressure suffered by the front buildings reaching 1.3 kPa. Conversely, that suffered by the rear buildings is only 0.18 kPa. (4) The airblast pressure loaded on the lower part of buildings is usually much higher than that on the upper part of buildings, i.e., the lower the position is, the higher the airblast pressure, and the severer the buildings being destroyed. (5) Under the attack of the airblast, the deformation of buildings can be divided into 5 stages, i.e., the elastic deformation stage, small cracks generation stage, rapid development of larger cracks, collapse of lower floors (i.e., preliminary collapse stage), and freefall stage of upper floors.

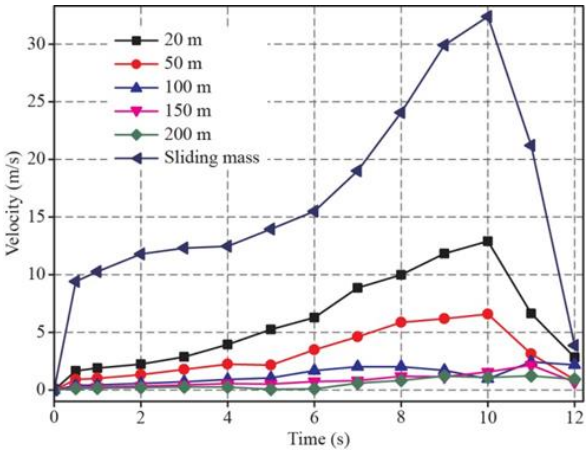

Fig. 1 Time histories of the velocities of the airblast in front of the sliding mass.

Acknowledgments

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Slope stability analysis of bioreactor landfills

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Abstract

Slope instability is a great concern for the operation of a landfill (Feng et al., 2017). There are two main slope failure types, including slide along the interface of liner systems and circular slide within municipal solid waste (MSW).

The objective of this study is to investigate the mechanism of slope instability of landfills. In-situ and laboratory tests were carried out to study the geotechnical properties of MSW and liner systems. Numerical simulation was also conducted to study the influence of hydraulic-mechanical properties of MSW and control measures (leachate recirculation and aeration) on the slope stability.

The experimental results demonstrate how the landfill height affects the slope stability. Results obtained from numerical simulation using a 3D model show that the anisotropy of MSW has a remarkable influence on slope stability and should be considered for the landfill operation. The minimum safe distance was also proposed with reference values for the design of leachate recirculation system (Fig. 1).

Two typical landfill cases were also analyzed using the proposed numerical model and the results were in good agreement with the monitored data.

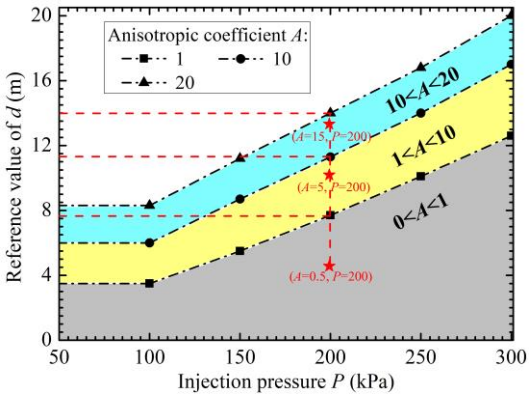

Fig. 1 Reference values of minimum safe distance between injection screens and landfill slopes.

Acknowledgments

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Experimental study on mechanism of rainfall-induced shallow loess landslides

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Abstract

Loess is widely distributed in northwest China, and it is a special type of geological material which is replete with randomly distributed defects of different orders, such as micro fissures, pores, and assorted joints. The unique structure with vertical joints developed inside and water sensitivity provides the rapid infiltration channel of water, and leads to the shallow failure easily in loess slope.

In order to effectively reduce the impact of landslides induced by rainfall on social and economic, it is of great realistic significance to carry out the study on rainfall-induced landslides. Three groups of indoor physical model experiments are designed and conducted in this paper, including loess slope with continuous heavy rainfall, loess slope containing a vertical joint with continuous heavy rainfall, and loess slope with intermittent heavy rainfall, respectively. Three kinds of sensors including volume moisture sensors, matric suction sensors and pore water pressure sensors were buried to record the internal changes in each loess slope. This paper surmises the failure mode and triggering mechanism of shallow loess landslides induced by rainfall, so as to provide a technical reference to prevent and control the rainfall-induced loess landslides in northwest China.

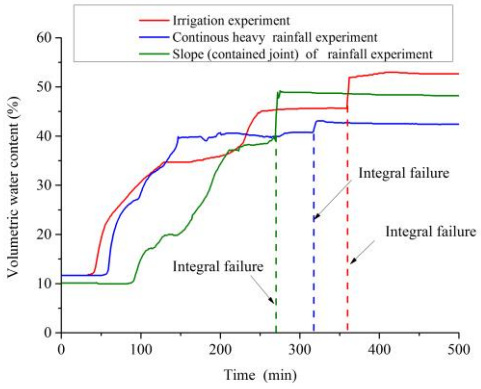

Fig. 1 Reading changes in volume moisture sensors

Acknowledgments

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A subgrade reaction solution for anchored piles to stabilize landslides

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Abstract

This paper develops a subgrade reaction solution for the response of anchored piles to stabilize landslides in which the sliding layer laterally moves with a displacement decreasing linearly with depth. Iteration was not necessary for the developed solution; however, the conventional solution had to use an iteration process to obtain the pile response. The subgrade reaction solution for unanchored piles was a special case of the developed subgrade reaction solution for anchored piles. Parametric studies clarified the influences of horizontal spring coefficient, prestressed load of anchor, movement gradient of the sliding layer, and the length of the pile segment in the sliding layer or the thickness of the sliding layer on the response of anchored piles.

An iteration process is proposed to select an optimum prestressed load of anchor that let the bending moment of the pile segment in the sliding layer equal to that of the pile segment in the stable layer. Thus the pile capacity to resist the bending moment can be fully mobilized. In addition, another equation is developed to calculate the maximum prestressed load of anchor that means the total anchor force, i.e., the sum of the prestressed load and anchor force induced by the movement of the sliding layer, equal to the allowable anchor force.

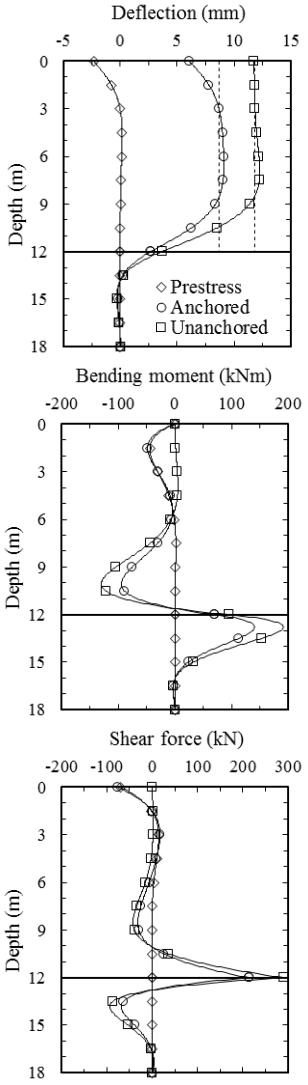

Fig. 1 Effect of prestressed load on pile response (broken lines stand for soil movements)

Application of regional physically-based landslide early warning model: field parametrization and validation of the results

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Abstract

The study is carried out in the Valle d'Aosta region that is located in North-West Alpine mountain chain. An in-depth study of the geotechnical and hydrological properties of hillslopes affected by shallow landslides was conducted, with the aim to improve the reliability of deterministic model, named HIRESSS (HIgh Resolution Slope Stability Simulator) (Rossi et al., 2013, Tofani et al., 2017). HIRESSS is a physically based distributed slope stability simulator for analyzing shallow landslide triggering conditions in real time and in large areas using parallel computational techniques. The software runs in real-time by assimilating weather data and uses Monte Carlo simulation techniquest o manage the geotechnical and hydrological input parameters. In this context, an assessment of the factors controlling the geotechnical and hydrological features is crucial in order to understand the occurrence of slope instability mechanisms and to provide reliable forecasting of the hydrogeological hazard occurrence, especially in relation to weather events. Two campaigns of on site measurements and laboratory experiments were performed. The data obtained have been studied in order to assess the relationships existing among the different parameters and the bedrock lithology. The data collected contributes to generate input map of parameters for HIRESSS (static data). The contribution of the root cohesion has been also taken into account based on the vegetation map and literature values. In particular, the model and the soil characterization were applied in back analysis, in order to assess the reliability of the model through validation of the results with landslide events that occurred during the period. The validation was performed on 4 past events of intense rainfall that have affected Valle d'Aosta region between 2008 and 2010 years triggering fast shallows landslides. The simulations show substantial improvement of the reliability of the results compared to the use of literature parameters. A statistical analysis of the HIRESSS outputs in terms of failure probability has been carried out in order to define reliable alert levels for regional landslide early warning systems.

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Deformation analysis of stone retaining masonry of the Kumamoto castle in the 2016 Kumamoto earthquake

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Abstract

In the 2016 Kumamoto earthquake, heavy damages to stone retaining masonry wall of the Kumamoto castle occurred. The field inverstivations of the danages were carried out by cooperating with the Kumamoto castle center. In the northern area of Kumamoto castle, slipping and separation between the ground slope and stone masonry wall was estimated to be caused due to strong ground motion of the earthquake. This wall was built by the traditional cunstruction method in the 16th century. A turret which is an important cultural asset, was stood on the stone wall before the earthquake but fell down by the collapse of stone wall.

We performed the numerical simulation of the wall collapse using two-dimensional Discontinuous Deformation Analysis (2D-DDA). This method is useful for simulation for the dynamic behavior of a large number of individual elements. The height of the wall model is about 20 meters. The behavior of stone masonry wall at each time shows in Fig.1. The input ground motion was estimated by the observed ground motion near the site. The collapse mode agreed with the actual damage of masonry wall of Kumamoto castle very well.

Acknowledgments

This work was supported by grant from the Ministry of Education, Science and Technology of Japan (No. 2630300701, 15K01259).

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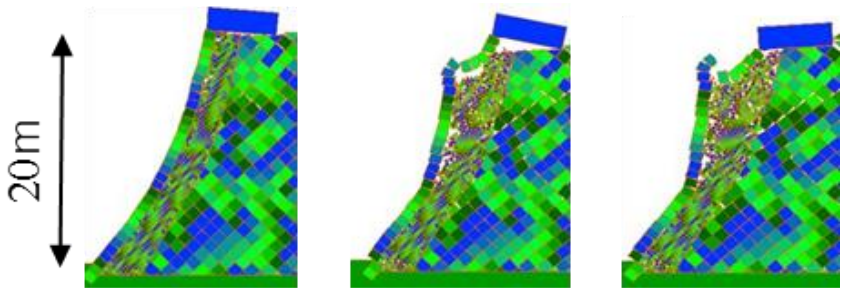

Fig. 1 Behavior of stone masonry wall

Experimental study on a deformation mitigation method for road embankment during liquefaction by using gravel and geosynthetics

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Abstract

A settlement and deformation of road embankment was occurred due to soil liquefaction during earthquake. Because it brings a serious damage such as cracks and gap of road surface, even emergency vehicles could not pass the road after the earthquake. Therefore, a liquefaction countermeasure technique for embankment by using geosynthetics sandwiched between gravel had been proposed (Murakami et al., 2010). Because the gravel has high permeability, it will be able to dissipate excess pore water pressure rapidly. Furthermore, because the geosynthetics has high-tension strength, the gravel layer with it will have high resistance against bending deformation due to overburden load of embankment. This method does not restrain the occurrence of liquefaction completely but mitigate the excessive deformation such as settlement and lateral movement.

Small scale shaking table tests in a 1-g gravity field were carried out to evaluate the effectiveness of deformation mitigation method for road embankment during liquefaction by using gyosynthetics sandwiched between gravel. The size of model embankment was scaled down one seventy-fifth of real embankment whose height was 4m and crest was 10m as shown in Fig.1. The gravel layer could dissipate the excess pore water pressure during liquefaction immediately, and restrained the shear deformation under the embankment because of its high permeability. Furthermore, the composite layer which consisted of the gravel with geosynthetics could perform as a rigid plate with high permeability. As a result, the improved layer could restrain the deformation of embankment, and this effect could keep shape of embankment.

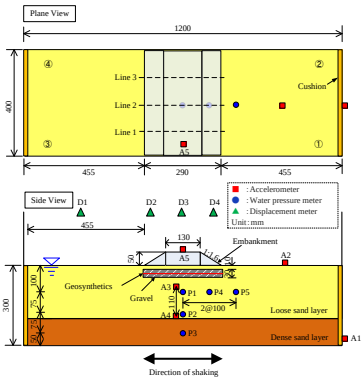

Fig. 1 General view of model ground.

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Effect of countermeasures against liquefaction of groundwater level by propulsion method

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Abstract

As a result of the liquefaction generated during the 2011 Tohoku Region Pacific Offshore Earthquake, the Chiba City Mihama Ward suffered significant residential damage. Chiba City established a liquefaction countermeasure committee, utilizing at 4-chome in Isobe, Mihama as the model district to undertake a study to investigate possible remediation solutions and the committees study concluded that a groundwater level lowering construction method was one such suitable solution. However, the groundwater level lowering method utilizing a sub surface drain installed by an excavation method (cut and cover), as previously implemented in Itako City and Kamisu City, had inherent problems, such as the resultant ground deformation during construction.

Therefore, the authors developed a new groundwater level lowering method in which a water permeable pipe (φ 300 mm) is installed beneath the road by way of mechanical jacking and a demonstration installation and analysis was undertaken at the Isobe Park at 4-chome in Isobe between October 14, 2014 to July 31, 2015. From the test results obtained, it was determined that the mechanical jacking method provides the same benefits as the excavation method. Based on the results of this experiment, the mechanical jacking method is now proceeding at 3 and 4-chome, Isobe in Chiba City.

At this symposium, we will discuss the current construction status and present the test results of the experiment to date and further expand on the monitoring plan.

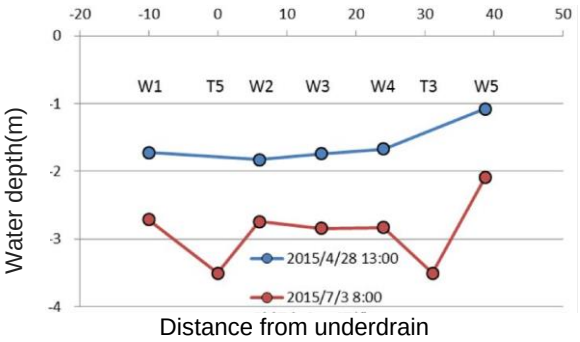

Fig. 1 Change in water level by underdrain method

Acknowledgments

This work was supported by the liquefaction countermeasure committee of Chiba city consisting of ground scholars.

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Experimental verification of groundwater drawdown method to be used in the liquefaction measures by jacking method, J.JSCE, Ser. A1 (2016) Structure・Earthquake engineering/Japan Society of Civil Engineers 72(4): 434-447.

Initiation of near-fault landslides subjected to pulse-like ground motions

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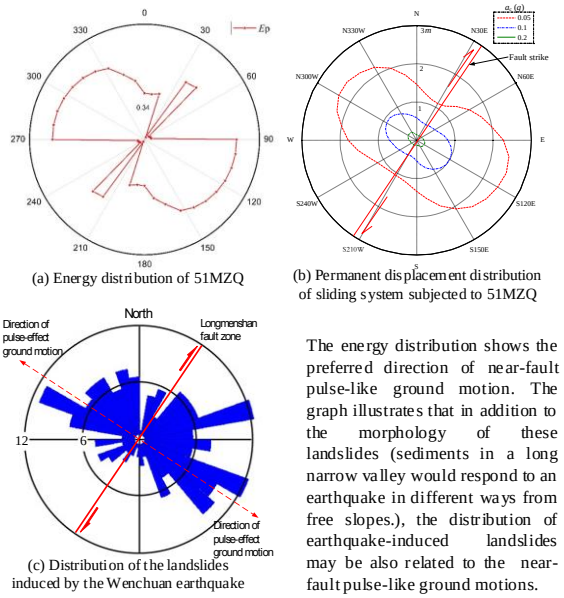
Abstract

Sliding of a rigid mass on an inclined, seismically vibration base serves as a conceptual and computational model for the evaluation of permanent displacement associate with landslides. This paper studied the initiation of landslides subjected to the near-fault pulse-like ground motion, including the initiation time and velocity, by analyzing the characteristics of the permanent displacement induced by near-fault pulse-like and non-pulse-like ground motions. Our results indicate the near-fault pulse like ground motions result in much larger sliding velocity and permanent displacement in a shorter duration than non-pulse-like ground motions. In addition to the well known dependence of the sliding system permanent displacement on variables such as the peak ground acceleration, the peak ground velocity, and the critical acceleration ratio, our study has consistently and repeatedly revealed a significant influence of permanent displacement on the directivity of sliding system in which the near-fault pulse-like ground motion is imposed. These results consist with the direction effect of earthquake-induced landslides distribution shown in field investigations.



(a) Energy distribution of 51MZQ

(b) Permanent displacement distribution of sliding system subjected to 51MZQ

(c) Distribution of the landslides induced by the Wenchuan earthquake

The energy distribution shows the preferred direction of near-fault pulse-like ground motion. The graph illustrates that in addition to the morphology of these landslides (sediments in a long narrow valley would respond to an earthquake in different ways from free slopes.), the distribution of earthquake-induced landslides may be also related to the near-fault pulse-like ground motions.

Fig. 1 Comparison diagram of (a) energy distribution, (b) permanent displacement distribution of sliding system subjected to 51MZQ, and (c) distribution of the landslides induced by the Wenchuan earthquake. (The diagram of the landslides distribution is modified from Chigira et al., 2010)

Acknowledgments

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Establishment of stereo multi-sensor network for giant landslide monitoring and its deployment in Xishancun landslide Sichuan China

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Abstract

Landslides are geological hazardous phenomena frequently occurring worldwide. They have been threatening millions of human lives and a number of infrastructures such as roads, buildings, reservoirs and power networks. Nowadays, techniques for slop surveying are increasingly developed (Qu et al., 2016; Ahmed, 2015). A variety of equipment and sensors have been adopted and quite a lot data has been acquired.

This paper aims to setting up a stereo multi-sensor network for a giant landslide monitoring. Some deformation tracking techniques such as Interferometric Synthetic Aperture Radar (InSAR), Ground Based Synthetic Aperture Radar (GB-SAR), Unmanned Aerial Vehicle (UAV), Terrain Laser Scanning (TLS) and Global Position System (GPS) are adopted to depict the slope movement discipline. Besides some borehole based sensors such inclinometers, soil moisture indicators and piezometers are installed underground to detect internal information. This study gives a detailed introduction towards the up-to-date surveying on giant landslide.

Acknowledgments

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Characteristics and mechanism of translational landslides in Three Gorges Reservoir, China

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Abstract

A lot of translational landslides have taken place in the Three Gorges Reservoir area. In order to study the characteristics and mechanism of the translational landslides, field investigations were conducted on several typical translational landslides. Excavated wells, trenches and testing tunnels were used to expose the surfaces of rupture, to observe the characteristics of the surfaces of rupture, and to sample in the typical translational landslides, such as Anlesi landslide and Huangtupo landslide. The research results show that the translational landslides crept along the incompetent interlayers and the contacting surfaces between the stratum and the soil under the long-term influence of tectonism and gravity, and the landslides might have several surfaces of rupture.

With the scanning electron micrograph, X-ray diffraction analysis and infrared ray analysis, the main mineral components and the microstructure changes of the zones of rupture surfaces were obtained. Triaxial compression tests and creeping deformation tests were performed on the rupture surface samples to study the coupling rules of water and soil. The research results show that with the combining effect of water-level change and continuous rainfall, water permeates to the strata through the tectonic fissures, resulting in high groundwater pressures in the fissures, and the shear strength of the surfaces of rupture and incompetent interlayers decreasing greatly.

The rainfall infiltration, groundwater level and displacements of the translational landslides were monitored to study the rainfall infiltration process and groundwater level change. Numerical modeling of the typical translational landslides was undertaken using the Geo-studio and FLac3D. The results demonstrate that groundwater level at the slope toe was controlled by water level rise, while the saturated area of the shallow slope surface was affected by continuous rainfall. The shear strain increment, displacement and failure area of the translational landslides increased greatly after the water level rose and continuous rained. Therefore, the translational landslides were induced by the combined effect of water level change and continuous rainfall.

Acknowledgments

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Paleo-earthquake study with drilling core in the epicenter of 1679 M=8 Sanhe-Pinggu earthquake along Xiadian Fault in Beijing Plain Area

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Abstract

In 1679 an earthquake with M=8.0 occurred in the east of Beijing,China, along an active fault called the Xiadian fault in Beijing plain. Xiadian fault is a normal fault with a 10km long scarp appeared on the ground surface and much more longer section buried by quaternary deposits.

The paleoearthquake trenching study across the scarp revealed at least 4 events occurred within 20ka. These events were defined by the collapse wedges, increasing layers and other abnormal phenomena correlating with the fault-formed micro-geomorphology.

A drilling study carried out in the epicenter of the M=8 earthquake of 1679 , revealed many kinds of paleoearthquake phenomenon in the drilling cores, such as the liquefactions, collapse wedge accumulations, soft soil disturbances, abnormal increased burial terraces, ground fissures and small faults. These phenomena are related to the fault-formed micro-geomorphology, shocking effects, and faulting deformation(Fig.1). Most of the phenomena were found in the deposition of the hanging wall of the Xiadian fault.

More than paleoearthquake 29 events were defined by the special phenomena. The time of each event is defined by the dating result of the disturbed or cover layers. The magnitude of each event is estimated from the offset of the fault which can be calculated from the difference of the depositing rates between the upper and low walls of the fault and the interval time. The 29 events distributing in 120ka is showed in Fig.2. The average recurred interval is approximately 2500a in 70ka.

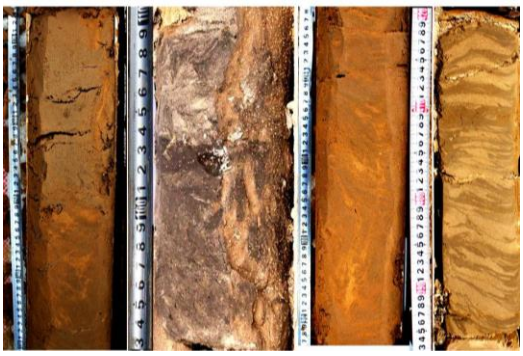

Fig. 1 Paleoearthquake phenomena on drill drilling cores

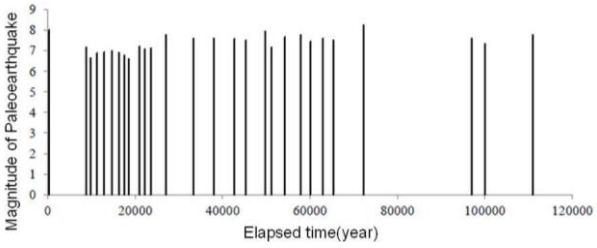

Fig. 2 Time distribution of Paleoearthquakes

Acknowledgments

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An empirical model to predict the debris flow volume

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Abstract

The estimation of the debris flow volume can be used to assess the debris flow hazards and provide a rational basis for the design of mitigative structures. At such purpose, estimation of the debris flow volume represents a valuable model for researchers involved in risk assessment and mitigation. This study develops an empirically-based models that predict potential volumes of debris flows in the Wenchuant earthquake area.

To establish a relationship between the predictor factors for debris-flow volume and the parameters observed in the terrain, 135 debris-flow were chosen and investigated in the Wenchuan area. Field surveys have been carried out to directly collect data and to verify those indirectly collected by air-photo interpretation and historical. Some data are also collected from publications. Catchment characteristics and the volume of sediment supply that could potentially influence debris-flow volume were measured and used in multiple regression analysis.

A stepwise multiple regression technique was used to develop empirical models for the determination of debris-flow volume using the variables that presented the highest correlation and a physical meaning. The independent variables used in the best subsets regression are then used in a linear multiple regression. On the basis of the MATrix LABoratory (MATLAB) functions and programming language, multiple regression models were used to determine the best model for the given data set. The independent variables selected by this analysis were the catchment area and the product of the sediment volume and the catchment relief. The regression equations were derived from the debris-flow data with 95% confidence in the coefficient of the variables in two model.

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Coupling problems of unsaturated soil slope due to rainfall infiltration

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Abstract

The seepage, deformation and stability in unsaturated soil slopes due to rainfall infiltration are important issues in environmental hazards. Theoretical solutions to 1D and 2D coupled infiltration and deformation in homogenous and layered soils are obtained using mathematical methods. Meanwhile, 1D and 2D hydro-mechanical model for an unsaturated soil is numerically developed. Coupling between seepage and deformation is considered. The solutions describe the transient pore-water pressure distributions of unsaturated soils during infiltration incorporating different boundary conditions. The solutions demonstrate that the boundary conditions also play a significant role in the pore-water pressure redistribution and coupling effect. Rainfall infiltration into a partially saturated slope of infinite extent can lead to a decrease of soil suction, compromising the slopes' stability. The rainfall infiltration coupled with deformation of a partially saturated soil slope during rainfall infiltration is analyzed. The limit equilibrium conditions and the shear strength relationship of unsaturated soils are employed to develop analytical solutions for computing the stability of an infinite unsaturated slope due to rainfall infiltration. The solutions can consider the influence of the coupled effects on the stability of the slope. The factors affecting the safety of an unsaturated slope of infinite extent are discussed. The results show that the hydro-mechanical coupling of water infiltration and deformation has an important effect on the infinite unsaturated slope stability.

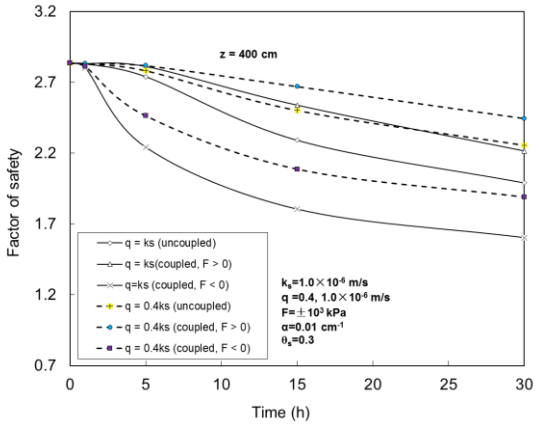

Fig. 1 The influence of rain intensity on F_s at a depth of 400-cm for an infinite soil slope

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Landslide soil parameters optimization based on successive approximation method

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Abstract

Landslide soil strength parameters play a key role in the landslide evaluation and management engineering design. Currently, the common value method is the inversion. The result of one section inversion is a variety combination of parameters. It would had mathematically overdetermined problem if there are multiple sections, which is not only one solution. Based on the optimization theory and method, the inverse problem transformed into a forward problem when the inverse problem of multi section inversion parameters is discussed in this paper. Constructing objective function, and using successive approximation method to inverse parameters indirectly, with the optimal values of the parameters being obtained. It achieved the goal that the strength parameters reflect the characteristics of sliding soil and suitable for each section. Combining with the experiment and inversion analysis results to determine the range of parameter values. Taking the Huangjiaoshu landslide as an example, and using successive approximation method to optimize parameters value. We obtained the optimized parameters for c=9.76kpa, φ=6.81°, and the results show that each section is consistent with the deformation state. This has a certain reference significance for landslide parameters value of landslide prevention engineering problem. However, this method is not applicable to all cases, only in the cases of needing to obtain a comprehensive set of parameters, with a certain reasonability.

Scientific Session

The 2010 - 2013 eruption of Kizimen Volcano, Kamchatka

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Abstract

Kizimen volcano is one of the active volcanoes located in the Central Kamchatkan depression. In July 2009, after a dormancy of over 80 years, the Kamchatka Volcanic Eruption Response Team (KVERT) reported first signs of increased seismicity [1]. Later during the year a weak thermal anomaly was detected in IR satellite imagery. Substantial ground deformation was shown by InSAR investigation indicating the ascent of magma in the uppermost crust (Ji et al. 2013). During 2010 and 2013 the volcano entered a new cycle of activity with several eruptions producing pyroclastic flows, lava flows and ash plumes resulting in heavy tephra fallout affecting several communities in the area (Dvigalo et al. 2013). In January 2011 the Tokyo Volcanic Ash Advisory Center (VAAC) [2] reported ash plumes of more than 10km height. Several air traffic warning bulletins were issued during this time until the end of 2013 when the volcano's activity ceased again. This investigation presents a detailed account of the eruption and summarizes results from fieldwork as well as petrographical and petrological data to highlight important aspects of the mountains recent activity. The presented data will substantially improve our ability to interpret renewed unrest on the mountain and provide background information when accessing effects and the impact of future eruptions.

Fig. 1 Eruption on March 2, 2011 with the new lava flow in the summit area, view from NE, courtesy by E. Vlasov

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Attempt of strain measurements for a landslide through distributed fiber optic sensing

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Abstract

Strain measurements for a landslide using distributed fiber optic sensors are now conducted in Izumo city, Shimane, Japan. The geology of the landslide area is middle Miocene Josoji formation. Main rock of the landslide is rhyolite. The landslide occurred in 2013 accompanied by the deformation of roads adjacent to it. Fourteen steel pipe piles were driven into the sliding mass in a line perpendicular to the dip direction in order to stop the landslide. The purpose of this study is to confirm preventive effect of the driven piles on the mass movement through the strain measurement of landslide surface.

Distributed fiber optic sensing system used in this study consists of a neural optical fiber scope (NBX-7020 by Neubrex Co., Ltd.) and a fiber optic cable (FR-OG4ETINHE-SR15E X 4C by Fujikura Ltd.). The scope can measure the difference in temperature and strain through the analytical technologies called PPP-BOTDA (Pulse-PrePump Brillouin Optical Time Domain Analysis) and TW-COTDR (Tunable Wavelength Coherent Optical Time Domain Reflectometry) for Brillouin and Rayleigh scattering, respectively. The cable includes 4 single-mode fibers covered by polyethylene sheath. The cable was laid on a ditch with its depth of 20 cm along the landslide surface in dip direction.

Figure 1 shows the layout of the cable in the landslide area. Because the dip direction curves in the landslide from the main scarp, the cable was also set in two directions in a measurement line. The cable is connected to the scope put in a monitoring house.

The measurements and data acquisition have been just started. Therefore, detailed settings of this study and results of the strain measurements will be presented in the symposium.

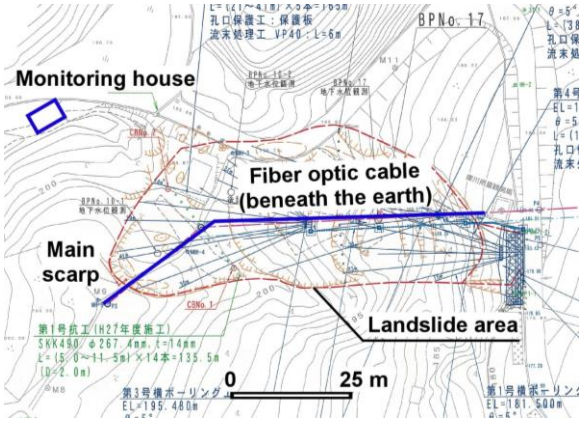

Fig. 1 Layout of a fiber optic cable in study area.

Acknowledgments

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Analysis of geogrids strain and failure surface of two-stage reinforced soil-retaining wall under seismic loading

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Abstract

In order to analysis of geogrids strain and failure surface of two-stage reinforced soil-retaining wall to horizontal seismic loading, the large-scale shaking table tests were performed. Experimental model is structured by backfill soil, wall and geosynthetics. The soil is standard sand, the wall is self-made model blocks and the geosynthetics is geotechnical grille. Input seismic waves are WL wave and EL-Centro wave, the peak accelerations is 1.2g of EL-Centro wave and 1.6g of WL wave. The loading cases were nine. By analyzing the data collected by the instrument, as the magnitude increases, the strain increases and the maximum strain point expands toward the interior of the soil. The strain at different locations are different. The potential failure surface increases gradually with the increase of magnitude. Based on the calculation method of all kinds of failure surface reference figure 1, the double-line failure surface considering the width of the platform is proposed, which can be used as the reference for the design and calculation of the two-stage reinforced soil retaining wall.

Acknowledgments

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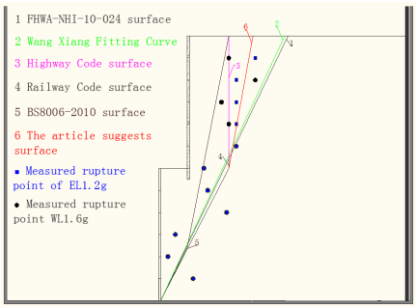

Fig. 1 Different calculation methods under the failure surface

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Fundamental shake table tests on mitigation of liquefaction-induced ground displacement by using gravel and geosynthetics

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Abstract

Liquefaction-induced ground displacement has imposed damages to structures during past earthquakes, for example, in the 2011 Great East Japan Earthquake and the 2016 Kumamoto Earthquake, Japan. Generally, due to major earthquakes and liquefaction triggered, important roads such as main roads, emergency evacuation routes, and roads connected to important facilities are inaccessible. This condition leads to the necessary to restrain liquefaction with economical methods that are simple to be implemented, in order to ensure that these vital roads remain accessible after earthquakes.

This study presents experimental results of a series of 1 g shaking table tests on soil models reinforced with gravel and geosynthetics subjected to liquefaction-induced ground displacement, both lateral and vertical movements. Initially, experiments associated with the mechanism of ground displacement based on the test without remedial measures (case 1) is presented, followed by the tests with remedial techniques by using gravel (case 2) and gravel combined with geosynthetics, respectively.

Furthermore, in order to obtain the additional results from the use of gravel and geosynthetics, further tests were done by varying the position of the geosynthetics in the gravel, which were at the bottom (case 3), in the middle (case 4), and at the top (case 5) of the gravel layer. General test results including time-histories of accelerations, pore water pressures and displacements are presented and discussed.

The results indicated that by applying the proposed mitigation measures, the seismic performance of the soil models can be improved by reducing ground surface lateral displacement around 20%, as can be seen in Fig. 1.

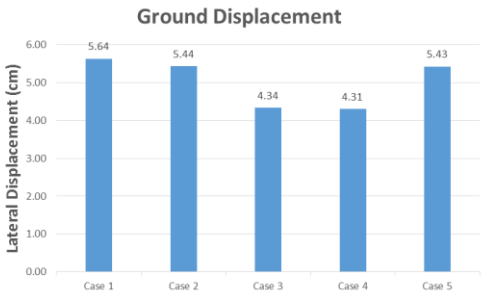

Fig. 1 Displacement of the ground surface

Slope safety evaluation by integrating multi-source monitoring information

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Abstract

Field monitoring is an important means to evaluate the safety state of slopes, provide basis for slope safety control measures, warn of impending failures and mitigate risks of slope failures. Einstein and Sousa (2006) emphasized that monitoring results and observations need to be properly interpreted to evaluate slope safety. Existing interpretation methods typically use one single index (e.g. surface or underground deformation, pore pressure, or rainfall) as a predictor and hence reveal only one aspect of slope performance. A holistic assessment of the slope safety state may not be achieved. Besides, a large portion of monitoring data is often not utilized in these methods. A systematic method is presented for evaluating the slope safety utilizing multi-source monitoring information in the present method. First, a Bayesian network with continuously distributed variables for a slope involving the factor of safety, multiple monitoring indexes and their influencing parameters (e.g. friction angle and cohesion) is constructed. Then the prior probabilities for the Bayesian network are quantified considering model and parameter uncertainties. After that, multi-source monitoring information is used to update the probability distributions of the soil or rock model parameters and the factor of safety using Markov chain Monte Carlo simulation. An example of a slope with multiple monitoring parameters is presented to illustrate the proposed methodology. The method is able to integrate multi-source information based on slope stability mechanisms, and update the soil or rock parameters, the slope factor of safety, and the failure probability with the integrated monitoring information. Hence the evaluation becomes more reliable with the support of multiple sources of site-specific information.

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Estimation of strong motion using H/V spectral ratio during 2016 Kumamoto earthquake

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Abstract

The damage estimation by an earthquake is required in the earthquake ground motion characteristic, the foundation dynamic characteristics of an object area, and the structural characteristic. However, it is difficult to evaluate earthquake ground motion simply because much information such as data of standard penetration test is required. There is a method using the horizontal-to-vertical (H/V) Fourier spectral ratios of microtremor observations as one of the method which evaluates an earthquake motion. Because this method is very easy and it is effective.

In this study, the method using the H/V Fourier spectral ratios of microtremor observations whose presumed accuracy improved is proposed. And the method takes into account of an attenuation relation for strong earthquake motions. By verifying this method, we use the 2016 Kumamoto Earthquake, Kumamoto Prefecture. We perform microtremor observations in these stations. For the example, the distribution of estimated peak ground velocity (PGV) at Oyatsu area are shown in Figure 1. As a result, we are able to perform more accuracy presumption of earthquake ground motion.

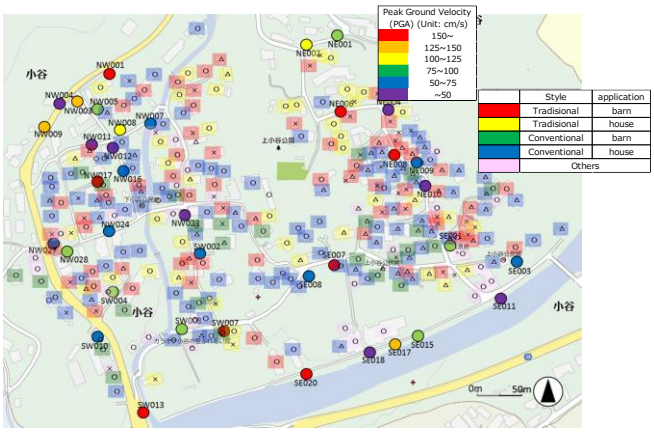

Fig. 1 Distribution of estimated peak ground velocity (PGV) at Oyatsu Area.

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A detailed inventory of landslides induced by the 2016 Kumamoto, Japan earthquake

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Abstract

The 2016 Kumamoto, Japan earthquake sequence began from an Mj 6.4 foreshock of 12:26 (UTC Time) on April 14, 2016 and reached a climax of the Mj 7.3 mainshock of 16:25 (UTC Time) on April 15, 2016, which caused 49 death of people and one missing. Despite moderate topographic relief and hillslope steepness of the affected area, the earthquakes have triggered a lot of landslides, some of which led to serious disasters, such as road burial and river blocking. According to several reports on earthquake hazards, four landslidesdirectly caused at least ten fatalities (Goda et al. 2016; Kayen et al. 2016; NZSEE 2016).

Databases and inventories of landslides triggered by major earthquakes have received much attention in recent years. These data are useful for understanding mechanisms and spatial patterns of earthquake-triggered landslides, characteristics of earthquakes, surface rupture, and seismogenic faults. In addition, detailed inventories of earthquake-triggered landslides are essential for landscape evaluation in quake-affacted areas and assessment and mitigation of debris flow and post-quake landslide hazards. Therefore, researchers established detailed landslide databases and inventories related to dozens of major earthquakes, such as the 2015 Gorkha, Nepal Mw7.8 (Xu et al. 2016), 2014 Ludian, China Mw6.1 (Xu et al. 2014a), the 2013 Minxian, China Mw5.9 (Xu et al. 2014b; Tian et al. 2016), 2013 Lushan, China Mw6.6 (Xu et al. 2015a, 2015b), the 2010 Yushu, China Mw 6.9, Port-au-Prince, Haiti Mw 7.0 (Xu et al. 2014c), and the 2008 Wenchuan, China Mw7.9 quake (Xu et al. 2014d). Apparently this subject will continue to be a focused issue of geosciences research in the future.

The aim of this study is to establish a detailed and complete inventory of the landslides triggered by the Kumamoto earthquake sequence. Based on high-resolution (0.5~2 m) optical satellite images before and after the earthquake, with the validation from ortho- aerial photographs with very high-resolution (better than 0.5 m) and oblique field photos, we delineated 3,467 individual landslides triggered by this event (Fig. 1). The total area of the landslides is about 6.9 km^2. Of them, 3,460 landslides are distributed in an elliptical area about 6,000 km^2, with a NE-SW directed 120-km-long long axis and a 60-km-long NW-SE short axis. Most of the landslides are shallow, disrupted landslides with a few flow-type landslides and rock and soil avalanches. The largest landslide (32.886°N, 130.983°E) occurred at the Aso Bridge, which is about 168,000 m^2 in area and 2.5 million m^3 in volume (Fig. 2). This landslide overwhelmed the Bungo highway and destroyed the Aso bridge across the river gorge, and resulted at least one death (NZSEE 2016). The coseismic landslides show a strong spatially nonuniform pattern; most of which (about 2,900 pieces) occurred

in the Aso Volcano area about 500 km^2. The correlations between coseismic landslides and several condition factors were analyzed. Results show the areas of elevation 1000-1200 m, strata of Q_3-H*vf*, seismic intensity VIII and VIII+, and peak ground acceleration (PGA) 0.4-0.6 g account for the largest landslide abundance.

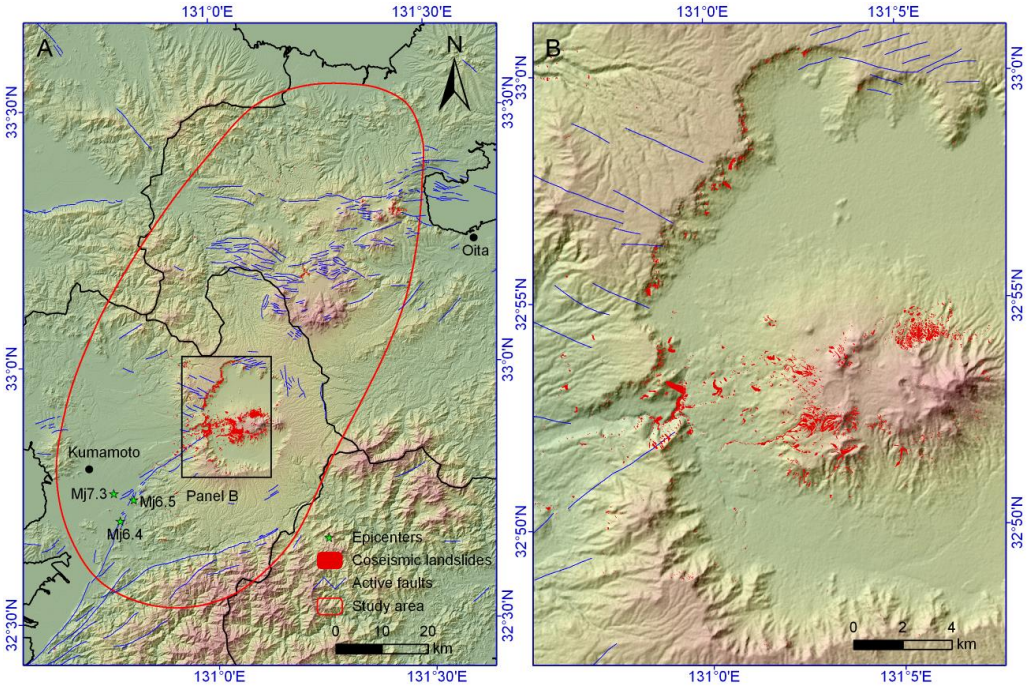

Fig. 1 Distribution map of landslides triggered by the Kumamoto earthquake. Active faults modified from Nakata and Imaizumi (2002) and Kato et al. (2016)

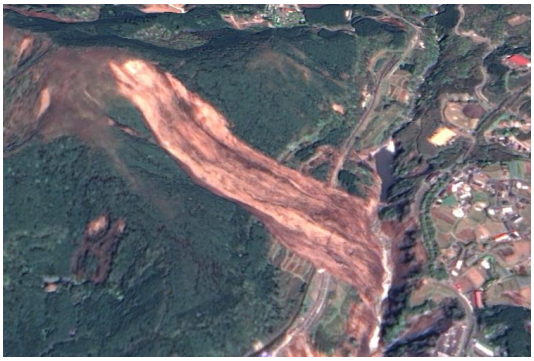

Fig. 2 Three-dimensional ZY3 oblique-image (2m resolution) of Aso Bridge landslide (32.886， 130.983). View to north, shoted on April 20, 2016

Acknowledgments

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An algorithm development for automated extraction of landslide geometry from LiDAR DEM: A novel landslide classification

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Abstract

A slide of the material downslope influences the morphology of a landslide. This paper presents development of an algorithm for an automated extraction of a landslide geometry to compute length, width, and area by implementing Numerical Integral Trapezoidal Rule (NITR) method from the LiDAR DEM (5 meters in spatial resolution). Every selected landslide polygon from the landslide inventory dataset has been automatically calculated using the WIDM algorithm we developed. The code was written in the MATLAB software to run analysis of geometry of the landslide. Also, this study introduces a novel taxonomical classification of landslides based on the geographical coordinates system associated with the geometry (i.e. length and width) of the landslide polygon occurred on the Earth's surface. We classified landslides as a)very long landslides, b) long landslides, c) very wide landslides, and d) wide landslides. This paper overcomes the shortcomings of the previous efforts by other researchers to analysis the length, width, and area of the landslides computed using usual geographic information system (GIS) techniques. The geometric analysis and classification model is called WIDM model.

Analysis and design of engineering control measures of sub-erosion vertical separated collapse at the national geological Park of Qian'an mud forest, China

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Abstract

Worsening collapse disasters are constantly taking place in the mud forest growth area in Qian'an County, Jilin Province, China. In 2013, certain control measures were implemented in areas that posed the highest threat to residential areas, but these measures ultimately failed. Disasters were not controlled, and the local landscape was seriously destroyed. This paper analyzes the causes of failure and finds that, unlike other common slope failure mechanisms, erosion caused by surface and subsurface water at the bottom of the slope is highly important in the formation of collapse disaster. The main cause of failure is the lack of consideration of subsurface erosion in the treatment design stage. In view of the disaster characteristics the hydraulic gradient determines the stability of soil particles in the flow field, and lowering ground water is the key to ensuring soil strength on the foot of the slope.

This paper discusses feasibility of several methods. To optimally protect the landscape of the mud forest, and horizontal drainage pipes are designed to interact with an intercepting ditch and anti-erosion construction on the basis of the formation mechanism of suffosion collapse. These treatments are conducted to quickly discharge the water from the slope and improve the stability of the slope, thereby ensuring the integrity of the mud forest landscape and ultimately protecting the landscape of the national geological park.

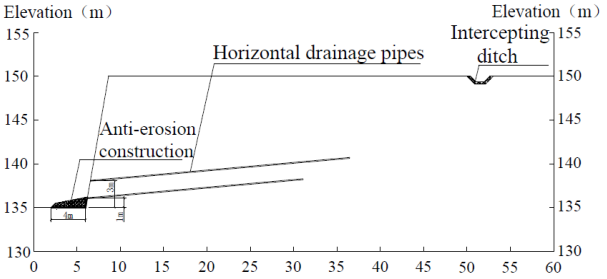

Fig.1 Profile of the new treatment methods

Acknowledgments

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Measurement of small strain shear stiffness of saturated soft clay by bender element

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Abstract

The small strain shear stiffness of soil plays an important role in many geotechnical engineering problems, such as machine foundation, ground response in earthquakes and soil liquefaction evaluation.

Bender element tests were used to measure the shear wave velocities of saturated Shanghai soft clay and therefore its small strain shear stiffness was determined. The effect of input frequency on the output signal was investigated, as shown in Fig. 1. It is clear that the input frequency has a notable effect on the output signal. At low input frequency, the near field is significant as expected. As the input frequency increases, the near field effect decreases. Meanwhile, wave component with high frequency and high velocity appears and it was recognized as the fast (first kind) P wave proposed by Biot (1956).

The effect of effective confining pressure on the shear wave velocity and small strain shear stiffness was also investigated. The results showed that the small strain shear stiffness increases as the effective confining pressure increase. Based on the tests results, an empirical equation was proposed to estimate the small strain shear stiffness of Shanghai soft clay according to its void ratio and effective confining pressure.

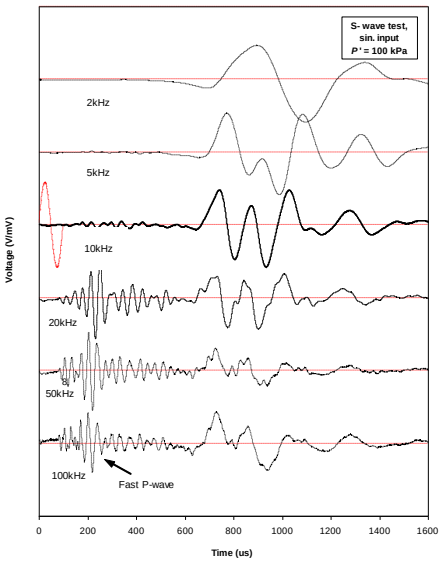

Fig. 1 Received signals at different input frequencies.

Acknowledgments

This work was supported by National Natural Science Foundation of China (Grant no. 51308408).

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Study on seismic isolation effect of deepwater gravel cushion

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Abstract

Gravel cushion, set up between base and foundation, is an effective isolation system, which has been verified by experiments and theoretical analysis.

Influence of cushion thickness, vertical pressure, particle size and other factors on isolating effect of gravel cushion was studied in this paper by micro-macro simulation and the results showed that when ground was given an increasing horizontal displacement at a stable rate, interlayer relative displacement would appear in cushion layers.

The maximum relative displacement appeared at the contact surface between ground and cushion and relative displacement of the lower cushion layers was larger than that of the upper layers; Smaller vertical pressure and cushion density, larger thickness of cushion and particle size helped to get a bigger seismic reduction ratio.

When vertical pressure increased, relative displacement and relative velocity between cushion layers declined, while acceleration of particles increased; When thickness of the cushion increased, damp rate of vibration in cushion speeded up and horizontal displacement of the upper structure at the same horizontal load increased significantly; And when cushion was made of larger particles, relative displacement between cushion layers increased and damp rate speeded up too.

It was recommended to use a thicker and medium dense cushion with larger circular particles in practical engineering.

Acknowledgments

This work was supported by the National Basic Research Program of China (Program 973) through Grant No. 2013CB036300.

Search for sliding surface of slope based on Dynamic Strength Reduction Method

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Abstract

Slope failure is a very common disaster in hilly regions, especially sliding disasters of heterogeneous rocky slope. The failure of slope is a progressive process where the whole sliding surface gradually evolves from the local damaged region in the slope. Based on the yield weakening of geotechnical material, a new sliding surface search method that can simulate the progressive failure of slope was proposed. The strength parameter of the damaged region was reduced, and then mechanical equilibrium of slope was calculated. Through the continuous local damage reduction of the strength parameters of the damaged slope body, the potential sliding surface damaged gradually and evolved to breakthrough finally (Fig.1).

The weak layer is closely associated with the stability of the heterogeneous rocky slope, but traditional calculation method is difficult to determine the failure mode. Present article mainly deals with the analysis of the stability of Dagangshan Mountain slope of Sichuan Province in China. The prevention flow of sliding disaster for heterogeneous rocky slope is presented. At first, Dynamic Strength Reduction Method (DSRM) was used to search the sliding surface, failure position and sliding direction. The case study of Dagangshan Mountain slope shows that DSRM is reasonable and correct when it is compared with the field observations. The study indicates that the sliding disaster of the slope is connected with f231 fault. The calculation results provide theoretical basis for the support and reinforcement program. In conclusion, DSRM provides a new calculation method for the stability and disaster forecast of similar heterogeneous rocky slopes.

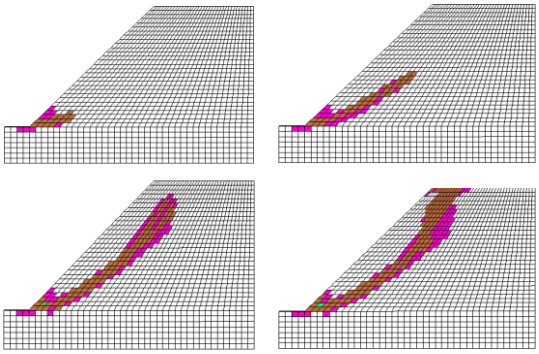

Fig.1 Evolution process of failure by the DSRM

Acknowledgments

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Experimental study on the liquefaction resistance of sand reinforced with randomly distributed polypropylene fibers

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Abstract

This paper presents an experimental study on the effect of randomly distributed fibers on enhancing the liquefaction resistance of sand. A series of undrained triaxial shear tests and hollow cylinder torsional shear tests were conducted on saturated sand samples with and without fibers. The influencing factors (including fiber length, fiber content and relative density) that are closely related to the liquefaction resistance of sand were investigated. The test results indicated that the samples reinforced with randomly distributed fibers can sustain many more loading cycles than the samples without fibers before liquefaction occurs; i.e., the inclusion of fiber can effectively improve the liquefaction resistance of sand. The liquefaction resistance increased with the increment of fiber length and fiber content. The reinforcement effect is found to be significant both in medium dense samples and loose samples. The test results in triaxial shear tests and hollow cylinder shear tests were similar to each other, indicating that different loading conditions in the two types of tests will not influence the reinforcement effect of randomly distributed fibers.

Keywords: Geosynthetics; liquefaction; polypropylene fibers; triaxial shear test; hollow cylinder shear test.

Research on heavy metal pollution of turf swamp under the influence of highways in Northeast China

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Abstract

Turf swamp, as natural habitats for much wildlife, are widely distributed in northeast of China. With the development of economic and construction, road engineering in the turf swamp has become very common. In recent years, the environmental impact on roadside soil in turf swamp was increasingly more serious. The road engineering construction has not only brought convenience to the transportation, but also brought heavy pollution to the soil along the road. With the intention to study the soil effect under the impact, the heavy metal pollution of turf swamp under the influence of highways was investigated in this study.

In this paper, soil samples were sampled perpendicular to the highway form two sites in Jilin province of China. Research on physicochemical properties and heavy metal content of different distances and deep onto roadside soil in turf swamp. The researchers compared soil samples characteristic and heavy metal contents and then analyzed the pollution pattern under the influence of highways in turf swamp. The results showed the relatively special properties of turfy soil, including high organic content, high water content, high void ratio, etc. It was found that Cd pollution was most serious, and the pollution level of Cu, Cr and Ni were different in different areas. In addition, Pb pollution has been decreased with the promotion of lead-free gasoline in recent years. The high water content of turfy soil was very favorable for the migration of heavy metal pollution in the vertical direction. And organic matter content also had a certain relationship with heavy metal pollution. The study may provide a better understanding for the shift of heavy metal in turf swamp and some help for the problem of heavy metal pollution along the highway in the future.

Acknowledgments

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On the mechanisms of loess flowslides within the framework of critical state soil mechanics

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Abstract

Critical state soil mechanics is commonly used as a framework for the interpretation of soil liquefaction, which was usually taken as the initial mechanism of loess flow slide in northern western China. Conventionally the critical state line (CSL) is unique for different soil states, intact or reconstituted and so the existence of two different lines raises new problems in the strength evaluation for the silty loess. For example, the soil states involved at particular engineering sites should be identified before using this method so that the correct line is used. For first time slope stability problems in the intact loess, the intact CSL should be adopted, while the reconstituted CSL might be more appropriate for problems encountered in loess disturbed to the point of remolding by previous slope failure processes, and for engineering applications where the soil is remolded or reconstituted. An error in selecting the correct CSL would cause the soil strength to be under- or overestimated significantly, for example in soil liquefaction potential. Since in v-p′space the critical state line for the intact loess is significantly higher than the intrinsic CSL, it is probable that even after an initial static liquefaction further remolding during the movement would cause a greater breakdown of the structure than is achievable in triaxial compression, causing the intact CSL to migrate to the remolded CSL, increasing further the pore pressures, giving additional liquefaction potential and softening instability This could contribute to the overall landslide movement, characterized by high speeds and long run-outs.

Uncertainty to explore suspected anomaly in the main impact zone of langtang snow avalanche

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Abstract

The Gorkha Earthquake of April 25, 2015 in Nepal completely devastated the Langtang valley and killed hundreds of human lives (Lacroix, 2016). The Langtang debris is a very challenging geologic environment for geophysical tests to identify suspected anomaly. Electrical Resistivity Tomography (ERT) would be a new attempt in exploring the suspected anomaly with regard to the missing people. It is a widely used method in detecting and investigating shallow depth targets/anomaly, but this is the first time this method was used in detecting buried people.

We used Spectral Element Method (SEM) to model the debris and surveyed boulder distribution in the disaster-hit area to understand the mechanism of snow avalanche, which could lead to identification of the main impact zone. Multiple cracks along with ground collapse observed in the surface suggest continuous rework of sediments by the sub-surface water. A 3D-ERT survey (Leucci and Greco, 2012) was carried out in eleven plots (each 35mx25m) (Fig. 1a). Different anomalies were identified and verified at different locations and at different depths of the plots. The results of 3D-ERT (Fig. 1b) along with the spatial distribution of boulders particularly in the main impact zone suggest uncertainty in finding any object of people's and military interest.

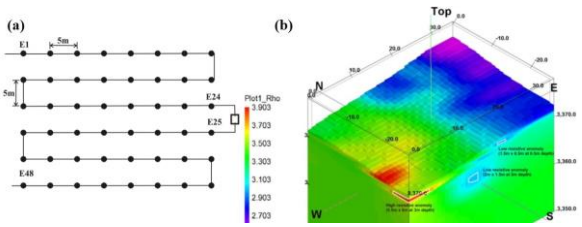

Fig. 1: 3D-ERT method (a) Electrode layout, (b) Location of Anomaly.

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Youth Forum

Frequency characteristics of acoustic emission in white marble under rock tests

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Abstract

Acoustic emission (AE) is defined as elastic waves associated with a rapid release of localized stress energy that is propagated within a material. It has been proven to be a useful tool for studying rock fractures (e.g., Amann et al., 2011; Shukla et al., 2013; Liu et al., 2015). Parametric and waveform data are two basic forms of recordable AE data. In the past few decades, parameter analysis has been widely used to observe progressive damage processes resulting from AE, as well as to evaluate the degree of damage (e.g. Xie et al., 2011; Zhang et al., 2015). However, a single complicated AE waveform still might conceal important information, or may even present misleading information, since it is discriminated by only a few parameters (Behnia et al., 2014). Thus it may be difficult to adequately discriminate the characteristics of AE waveforms using such parameter-based approaches.

In waveform-based approaches, spectral analysis methods are often used for signal waveforms analyses. Because frequency content in an AE is determined by the wave source, studying the dominant frequency characteristics provides significant controls on investigations of microscopic fractures. However, some latest studies about the dominant frequency of AE waveforms (Lai et al., 2015; Zhang et al., 2016) still did not involve the statistical analysis.

The objective of this paper is to present the dominant frequency characteristics of AE waveforms of marble samples acquired during direct tensile, shear and uniaxial compression tests, and then briefly discuss microscopic failure mechanism according to statistical characteristics. For this purpose, an improved signal processing method was proposed. AE waveforms tested samples were obtained and analyzed. The amplitude characteristics of the AE waveforms were presented and discussed for various stress stages. Furthermore, microscopic failure mechanism was revealed using the first motion polarity method.

The white marble samples were taken from Baoxing in the southwestern of China. These marble samples consist only of calcite, which has been measured by X-ray diffraction. The rock mechanics test system (Model: MTS815 Flex Test GT) was employed for the direct tensile, shear and uniaxial compression tests. A three-dimensional real-time monitoring system (Model: PCI-2), was applied in automatically capturing the AE signal waveforms during the micro-cracking processes leading up to failure.

It is discovered that the characteristic of double dominant frequency bands is an intrinsic characteristic of micro failure of rock and there is no obvious difference in the scope of high and low dominant frequency bands and the central frequency band of different rocks under different loading conditions.

In general, the proportion of low dominant frequency band signals is higher than high dominant frequency band signals under direct tension. However, the signal proportion of high dominant frequency band is obviously higher than that of low dominant frequency band in rocks under shear.

An analysis is made to the micro failure mechanism of uniaxial compression test samples of several kinds of rocks based on the polarity value method and the moment tensor analysis method. A brief discussion is made on similarities and differences concluded from analysis of two kinds of micro mechanisms. A contrastive analysis is made to the relationship between the proportion of shear failure in the micro failure mechanism of rock and the proportion of high and low dominant frequency band signals and a comparison is made for the change rule of micro shear failure and high and low dominant frequency band signals with stress state. It is believed that the characteristic of double dominant frequency bands of acoustic emissions in rock reflects the micro failure characteristic of rock, micro shear failure generates a signal with the characteristics of high dominant frequency and micro tensile shear releases a signal with the characteristic of low dominant frequency. An inverse analysis and a reasonable explanation are made based on the micro failure mechanism to dominant frequency characteristics and phenomena of acoustic emissions in all test samples.

Acknowledgments

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Preliminary investigation on the formation mechanism of geomorphic features in Luanshibao rock avalanche

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Abstract

Rock avalanches with long-runout distances, high speeds and large volumes usually lead to severe damage and major disasters. The geomorphic features of rock avalanches are the significant geological evidences for back analysis of its kinematics and dynamics mechanisms.

Luanshibao landslide is located at the northeastern margin of the Maoyaba basin, which is on the eastern margin of the Tibetan Plateau (Guo et al., 2016). The planform morphology of the Luanshibao landslide is with a long tongues shape, and the maximum runout and deposited width of the rock avalanche are about 3.8 km and 2.0 km. The total area is about 4.0 km^2.

The landslide is characterized by three major zones: source area (I), transportation area (II) and accumulation area (III) (Fig. 1). The accumulation area is with complex geomorphic features including transverse ridges, longitudinal ridges, conjugate troughs and hummocks. There are three sub-zones: transverse and longitudinal ridges area (III-1), conjugate troughs area (III-2) and hummocks area (III-3). Field evidence, supported by morphometric and sedimentary analysis of clastic deposits, has demonstrated that the control on the depositional mechanism is revealed by the compression and extension evolution both in time and space due to clastic deposits and substrate interaction.

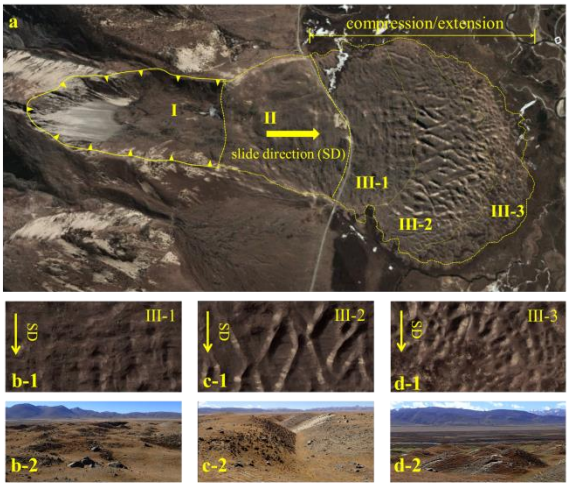

Fig. 1 Geomorphic features in Luanshibao rock avalanche

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Monitoring activity at the Daguangbao mega-landslide (China) using Sentinel-1 TOPS time series interferometry

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Abstract

The Daguangbao landslide, caused by the 2008 Wenchuan earthquake, is one of the largest landslides in the world. The whole Daguangbao mountaintop collapsed in the 2008 earthquake, leading to a height change up to 500 meters. Due to its wide coverage and inconvenient transportation, it is hard to study it with traditional methods. Space-borne InSAR technology provide us the capability of measuring and monitoring the landslide in a new way.

In this study, we propose a re-flattening iterative method to generate a high-precision post-seismic DEM with the TerraSAR-X/TanDEM-X(TSX/TDX) SAR data. With the pre-seismic and post-seismic DEM, the volume of this landslide is calculated, which is in good agreement with the geological investigation results.

15 Sentinel-1 SAR images were acquired during March 2015 to March 2016. The time series displacements of the Daguangbao landslide are obtained using our advanced InSAR TS+AEM method with the Sentinel-1 SAR images and high-resolution post-seismic TSX/TDX DEM. Four active zones are observed with a maximum displacement rate of 8 cm/year, suggesting that this landslide is still active even 8 years after the earthquake.

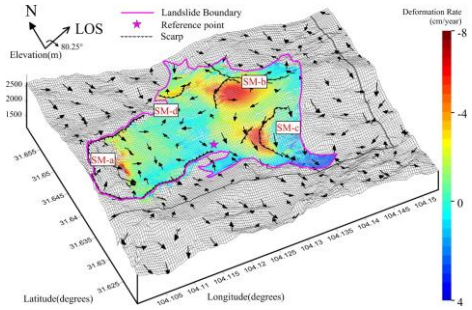

Fig.1 Displacement of Daguangbao landslide

Acknowledgments

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A study on sediment disaster prediction method based on measurement of ground water level in slope

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Abstract

In Fig.1, the vertical and horizontal axes show the hourly precipitation and the Soil Water Index(SWI) calculated by three tanks model, respectively. The snake line is time step line that can be drawn using hourly precipitation. When the snake line exceed the CL that is warning level line, an alert is raised. Though, the red line in Fig.1 is drawn by using precipitation of the time when sediment disaster happened, it does not exceed CL. Over 70% of sediment disasters in Ishikawa, Japan were not published any alert. To improve the hit rate of sediment disasters occurrence, there may be two methods. One is adoption the smaller CL such as dotted line in Fig.1. In this case, another two snake lines exceed the smaller CL, the many false alarm will be published. The other method is to develop new suitable SWI and re-define the CL. The precipitation in disaster will be categorized into three patterns by the inclination of snake line as shown in Fig.1, the first is torrential rain, second is continuous rain and last one transitional rain. This precipitation type may be specified by the geological and geomorphological features. On the other hand, the present criterion can not express the differences of the above features. Then, we are trying to develop new CL based on actual water level in slope. The water level in slope is one of very important points in the slope sliding mechanism. It is able to be thought that the original SWI does not express actual water level for slope failure. In this study, the measurement of ground water level in three slopes are carrying out, and we defined the new CL using the actual ground water instead of SWI. It is confirmed that the new CL method can be estimate sediment disasters with reduction of misjudgment ,and without consideration of precipitation type.

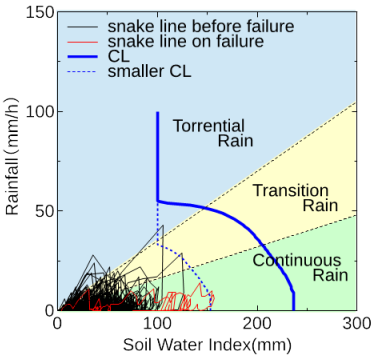

Fig.1 The relation between Landslide Alert Information and the type of rainfall

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An integrated hydrodynamic model for runoff initiated debris flow in mountainous catchments

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Abstract

Debris flow is one of the most common natural hazards in mountainous catchments. Intense rainfall can cause significant runoff to initiate debris flow. Runoff generated debris flow can cause enormous loss of lives and properties. For example, the Zhouqu debris flow happened in 2010 in China caused more than 1400 deaths and economic loss over 17.7 million US dollars of estimation. As a complex phenomenon, the life span of a runoff generated debris flow involves several different stages: firstly, intense rainfall generates overland flow and overland flow converges into channels to form channel flows. Secondly, channels may be eroded in the form of shallow landslides or grain by grain by hydrodynamic forces. Thirdly, mixture of sediment and water is routed via the channels. At last, the sediment settles down when the flow reaches flat planes.

Computer models are indispensable tools to quantify the risk of debris flow and understand the mechanics of debris flow. Until now, many models have been developed for simulating debris flow. (Hutchinson 1986) developed a simple lumped mass model for landslides and debris flows. Since the pioneer work of (Savage & Hutter 1989), depth-averaged models are becoming increasingly popular and have been widely used today (e.g. (Iverson & Denlinger 2001; Medina et al. 2008; Armanini et al. 2009; Ouyang et al. 2014; Chen & Zhang 2015). However, very few of them are able to simulate the whole process of runoff initiated debris flows. (Chen et al. 2016) developed an integrated physically-based framework to quantify the risk of rainfall induced landslides and debris flows in catchments. However, the initial volume of debris flow is still not computed in a physical-based manner. A fully physically-based model for simulating the whole process of runoff initiated debris flow has not yet been developed.

To fill in this research gap, an integrated physically-based model that considers simultaneously rainfall runoff, erosion/deposition and debris flow routing has been developed. A hydrodynamic approach based on solving depth-averaged equations is adopted to simulate the rainfall runoff. To enhance the efficiency, accuracy and stability of simulating rainfall runoff, an efficient and stable numerical scheme for overland flow (Xia et al. 2017) has been developed and adopted in this model. A new depth-averaged formulation of free surface flow for steep and curved topography is derived to increase the accuracy of debris flow routing simulation on mountainous catchments. The quadric rheological law of (Julien & Lan 1991) and Takahashi's equation (Takahashi et al. 1993) are adopted to model the basal resistance and erosion/deposition rate respectively. The integrated model is implemented on GPUs

for much improved computational efficiency to support catchment-scale (~100 km^2) simulations. After being validated against simple test cases, the model is applied to simulate debris flow in Zhouqu, China, 2010 and satisfactory agreement with field observations has been achieved. The model is shown to be a powerful tool to assess the risk of debris flow in mountainous catchments.

Acknowledgments

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Effects of damage on performance of hospital in the 2016 Kumamoto earthquake

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Abstract

A questionnaire survey for medical institutions affected by the 2016 Kumamoto earthquake was done and the influence of earthquake damage on medical functions was quantitatively evaluated. The questionnaire was conducted at the areas where suffered damage to buildings and lifeline functions. The target hospitals are institutions having a bedside. As a result, a questionnaire survey form was mailed to 389 medical institutions. The responses were obtained from 125 medical institutions. The questionnaire collection rate was, therefore, 32.1%.

Building damage and lifeline function damage as main item of damage are shown below. Damage to structural members occurred in medical institutions at outer wall in 62% of the total number of institutions and inner wall in 67%, but about 10% of medical institutions answered that they had an influence on medical function. In addition, damage to non-structural members occurred at floor in 30%, ceiling in 39%, and institutions affected on medical function exceeded 20%.

Figure 1 shows that lifeline function damage occurred in a medical institution with a blackout of 54% and a water shortage of 52%, gas supply interception of 35%. The institutions that had an influence on medical functions were 52% at the time of blackout and 71% at the water shortage and 57% at the gas supply interception. The water shortage had a most bad effect on medical function because of malfunction of water supply/drainage facilities. It is clarified that the damage to the lifeline function has a large influence on the medical function.

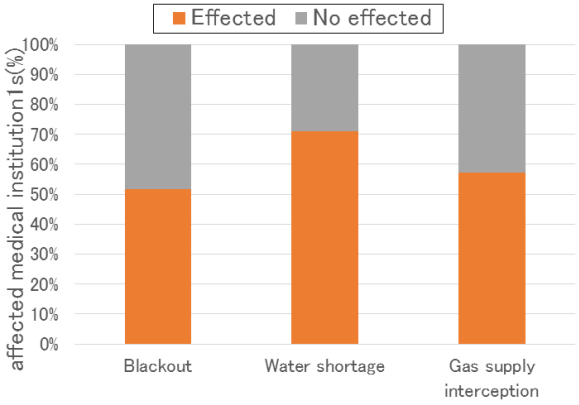

Fig. 1 Impact of lifeline function damage.

In order to understand to what extent the medical function declines due to various damage occurred in the medical institution, we carried out Quantification 2 analysis which is one of the multivariate analysis methods. The result was similar to single correlation analysis mentioned above. It was found that the influence of damage to water supply/drainage facility and water shortage on medical malfunction was large.

Acknowledgments

We appreciate the medical institutions for cooperating with the questionnaire survey.

Effect of bedrock terrain on seismic ground motion

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Abstract

Based on theoretical analysis, the spectral element method is used to study the effect of bedrock terrain on ground motion. The achievements are as follows: (1) The intensity of bedrock ground motion is related to bedrock occurrence, incident orientation of seismic wave and other factors. The incident orientation of seismic waves is closer to the tangent direction of bedrock surface, and the intensity is smaller. On the contrary, the incident orientation is closer to the normal direction of bedrock surface, and the intensity is stronger. (2) The presence of bedrock with convex terrain leads to weakening of the surface intensity of ground motion, and thus to the formation of the relative weakening zone of ground motion intensity. While, the presence of bedrock with concave terrain leads to strengthening of the surface intensity of ground motion, and thus to the formation of the relative enhancement zone of ground motion intensity. (3) Under different bedrock topographic dips, there are different relative variation zones of ground motion intensity. Under the action of the bedrock with convex terrain, the relative weakening zone of ground motion intensity is 1.13～1.69 times larger than the bedrock convex area, which increases gradually with the increase of bedrock topographic dip. Whereas, under the action of the bedrock with concave terrain, the relative enhancement zone of ground motion intensity is 0.5～1 times smaller than the bedrock concave area, which decreases gradually with the increase of bedrock topographic dip. (4) Under different cover layer thicknesses, there are different relative variation zones of ground motion intensity. Under the action of the bedrock with convex terrain, the ratio of the relative weakening zone ground motion intensity to the bedrock convex area increases gradually with the increase of cover layer thickness. However, under the action of the bedrock with concave terrain, the ratio of the relative enhancement zone of ground motion intensity to the bedrock concave area decreases gradually with the increase of cover layer thickness.

Acknowledgments

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Simulation of vehicle toppled phenomenon induced by the 2016 Kumamoto earthquake using 3D-DDA

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Abstract

Kumamoto earthquake which happened on April 15th, 2016 caused severe building damage and personal casualty, and during field investigation near Minami Aso bridge (in Minami Aso Village) we found some toppled vehicles. The problem we are trying to solve in this paper is how to simulate the extreme motion so that we can make inversion of earthquake acceleration wave and PGA nearby. In order to solve this problem, we used discontinuous deformation analysis method which has been programmed to simulate this extreme motion. Since there are no stations in Minami Aso Village, we used an earthquake acceleration wave which was simulated by a researcher in our laboratory as an original earthquake acceleration wave, and then found the multiple of this acceleration wave which could topple the car model. After plenty of experiments, the results of recent study include that the inversion earthquake acceleration wave, and from which we can know the PGA. On the other hand, according to the results of experiments, the weight distribution of vehicles should be as even as possible, if engine part of a car is heavier than other parts, this car tends to be toppled more easily. In general, the 3D-DDA program can now be used to simulate vehicle response when earthquake happens, which can also be taken as a reference to estimate the PGA values.

Influence of grain size distribution on the mobility of polydisperse granular flows

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Abstract

A series of laboratory experiments was conducted in a small flume to better understand the influence of grain size distribution on the mobility of polydisperse granular flows.

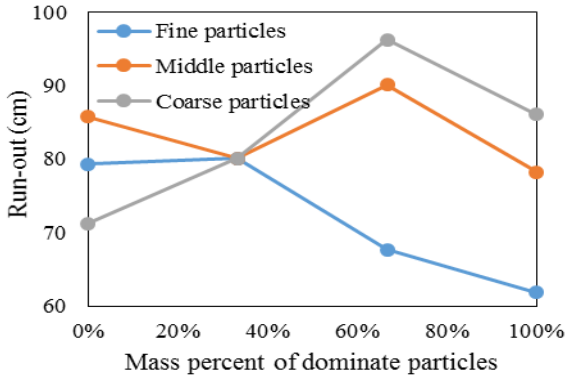

Fig. 1 Runout of various polydisperse granular flows.

Test results indicates that interaction between particles with different grain size enhanced the mobility of granular flows. With increasing proportion of fine materials, the run-outs increased and then decreased. This conclusion agreed with that drawn by other researchers (Goujon et al., 2007; Phillips et al., 2006; Yang et al., 2015). This was because that a certain amount of fine particles served as rollers and excessive fine particles locked neighboring particles. Furthermore, the mobility of polydisperse granular flows reduced with few or excessive middle particles, while increased with moderate quantity middle particles. The run-out of polydisperse granular flows was controlled by the mobility of mass front.

Acknowledgments

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Post-seismic vegetation recovery and landslide changes after the Wenchuan earthquake

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Abstract

The M_W 7.9 Wenchuan earthquake caused dramatic vegetation destruction by triggering massive coseismic landslides. After the major shake, vegetation at coseismic landslide sites has been continuously recovering. At the same time, landslides have also been changing. In previous research, post-seismic vegetation recovery has been extensively studied using low spatial but high temporal resolution remote sensing images, whereas landslide changes have been studied by high spatial resolution images with long time interval. In this work, we compare the changes of post-seismic landslides with vegetation recovery to explore their relationship. We found that post-seismic vegetation recovery derived from low spatial resolution images is positively correlated with landslide area decrease mapped from high spatial resolution images. We further found that post-seismic vegetation recovery can be used to indicate the stability of hillslopes disturbed by coseismic landslides. In addition, landslide changes derived from high spatial resolution images can be used as a validation data for vegetation recovery derived from low spatial but high temporal resolution images, whereas the later has the capacity to track the dynamic processes of post-seismic landslide changes. We recommend a combined use of both datasets to study the evolution of post-seismic landslide evolution. Finally, we predict that landslides caused by the 2008 Wenchuan earthquake may disappear by 2025 from interpolation.

Acknowledgments

This work was supported by the National Key Research Project of China through Grant No. 2016YFC0501604-05.

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Effects of liquefaction damage to houses on health problems in the 2016 Kumamoto earthquakes in Japan

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Abstract

At 21:26 JST on April 14, 2016, an Mw 6.2 earthquake struck Kumamoto City in Kyushu, Japan. About twenty eight hours later, at 01:25 JST, an Mw 7.0 stronger earthquake occurred in the same area. Liquefaction damage occurred in Kumamoto City, and differential settlement of houses became a big problem. As a result, health disorder appeared in residents, resulting in loss of usability and functionality as houses. Previous studies have revealed the influence of inclination of houses on health condition, and it is known that dizziness and associated sickness gradually occur when the inclination angle exceeds 1/100 (0.6 °)[1)]. In this study, field investigation and inspection were conducted to study an effect of inclination of a house due to liquefaction on health problems of residents.

Damage to structures caused by liquefaction in Kumamoto City has not occurred over a wide range but in the band-like range. Therefore, it is thought that not only countermeasures against large-scale liquefaction but also countermeasures focusing on each house are necessary.

The inclination angle of 68 houses and buildings in liquefied sites of Kumamoto City was measured. Figure 1 shows the distribution of the number of damaged buildings by inclination angle. Approximately 30% of the surveyed houses are inclined to 0.6 ° or less, while the remaining about 70% is the inclination amount related to health problems. It has been confirmed that the inclination causes health problems and obstacles to daily life from interview to the residents in liquefied sites.

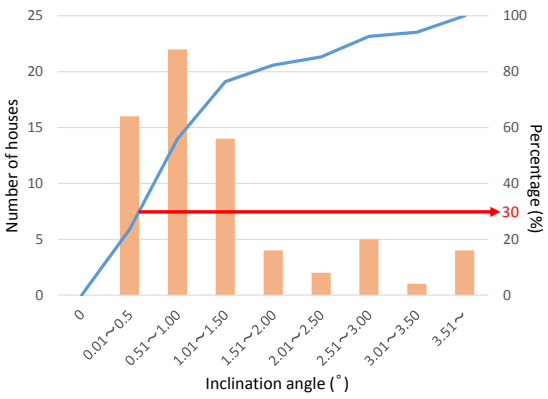

Fig. 1 The percentage of the inclination angle

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Comparison of major statistical methods and its combination for landslide susceptibility mapping

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Abstract

Landslide risk exists with the mountain regions and every year creates a great life and financial losses. To prevent the disaster numbers of statistical methods have been proposed, but it is still not clear if you want one specific reliable method for the landslide susceptibility mapping and yet very few studies proposes a reliable method, all of these methods has its strength and weaknesses, therefore, this study is to compare the commonly used statistical methods “Frequency Ratio (FR), Weight of Evidence (WOE), Logistic Regression (LR) and the combination of the methods” to find a specific reliable method for the landslide susceptibility mapping.

To implement these methods Kabul city, the capital of Afghanistan, which has the area of 275 km2 and is the home for around 4.5 million people is considered. The landslide susceptibility maps were created considering the landslide triggering factors such as "Elevation, Slope Angle, Precipitation, etc,".

To evaluate the accuracy of the analysis 173860 control point equally divided from the landslide and non-landslide area is chosen and Matrix validation method is used. The result proposes that the combination of the statistical methods increases the accuracy of the analysis and because of 77.06% of the success rate, the combined method of Weight of Evidence (WOE) and Logistic regression (LR) is reliable for the study area.

Strain rate analysis in San'in area using GNSS data

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Abstract

GNSS Earth Observation Network System (GEONET) was launched by the Geospatial Information Authority of Japan (GSI) in 1994. GEONET revealed the pattern of the surface crustal movement. Sagiya et al. (2000) used the technique and found Niigata-Kobe Tectonic Zone (NKTZ) where strain rate was large. Actually, many earthquakes occur along this zone. On the other hand, major earthquakes such as the 2000 Tottori Western Earthquake (M7.3) and the 2016 Middle Tottori Earthquake (M6.6) occurred in the San'in area. Therefore, strain rate in San-in area is also expected to be large. The purpose of this study is to find strain concentration zones in the San-in area considering the distribution of strain rate in high resolution calculated from GNSS data.

We used the GNSS daily coordinates called (so-called the GEONET F3 solution) provided by GSI (Nakagawa et al., 2009). We calculated only the trend component of displacement rate although GNSS data itself includes the effects of some parameters such as annual and semi-annual trend of deformation or step deformation due to earthquakes. The horizontal displacement at each observation point was aligned to lattice point with interval of 0.1 degree obtained by Nearest Neighbor method in Generic Mapping Tools (GMT). The maximum rate of shear strain was calculated by differentiating displacement rate with respect to the distance among each lattice point. Results show that the distribution pattern of the strain rate changes with time and observation period. The largest strain rate of about 200 nanostrain/yr is found in Middle Tottori and around Mt. Sambe, which is an active volcano in Middle Shimane.

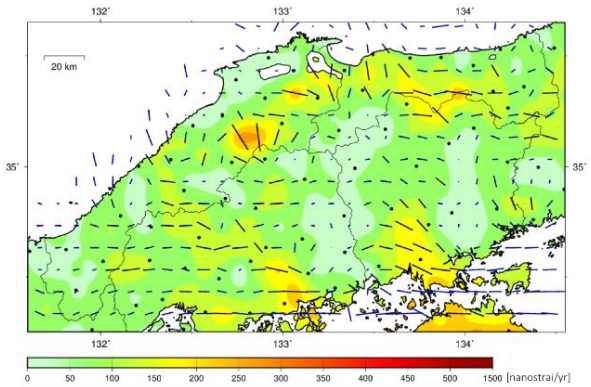

Fig. 1 Maximum Shear Strain from 2012 to 2015 by GNSS data.

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Gu dian fault: triggering seismic fault of *MS* 7.0, in 1119 AD, Northeast China

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Abstract

Occurred in 1119 the MS6 delighted many customers and earthquake is a bigger earthquake magnitude in the northeast, because of the seismogenic area for large continental sedimentary basins, sedimentary thickness is big, seismogenic fault there have been controversial.

On the basis of geophysical data, this paper analyzes the regional deep geological structure, determine the earthquake zone is located in the two tectonic units of contact boundary (central sag tectonic zone and southeast uplift tectonic zone), on the boundary of the two tectonic units, the Gudian fault.

In order to further determine the activity of Gudian fault, carried out the high resolution shallow seismic exploration, find out the Gudian fault underwent early and late extruding inversion of two stages. Fracture since quaternary period in order to obtain the latest activities of information, the across fault detection of drilling, using the drilling of thrust fold growth strata formation, cooperate with the quaternary chronology data, find out the Gudian fault time has entered the late pleistocene, the latest activity of active faults.

The nature of the geological and faulted activities in the comprehensive region determined that the Gudian fault was broken in 1119.

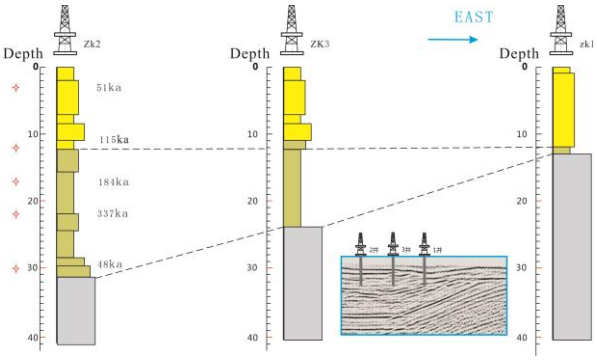

Fig. 1 activity of Gu dian fault..

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Antecedent effective rainfall attenuation model in the forecasting of impending debris flows

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Abstract

In the short-term forecasting of impending debris flows, the primary task is to determine the critical rainfall threshold of the debris flows caused by rainfall. When the rainfall reaches the threshold of critical rainfall, then the large-scale debris flow will occur. However, the antecedent effective rainfall has important influence in the determination of critical rainfall threshold, and a relatively accurate and effective rainfall can improve the accuracy of short-term forecasting of impending debris flows. The attenuation law of antecedent effective rainfall is the attenuation law of moisture content in provenance which is prone to debris flows. In this paper, a new antecedent effective rainfall attenuation model is established by the onsite attenuation test of moisture content in Gan Gou village and this model can have great fitting calculation for the attenuation law. Due to the fact the elevation, slope, climate, sunshine condition, vegetation coverage, land - use, size, rainfall and soil texture and other internal factors of debris flow in different areas are different, It's necessary to do the moisture content test on site to obtain the model parameters before the prediction of debris flows. Under the premise that each rainfall process is independent of each other, the total antecedent effective rainfall attenuation model was obtained by the linear superposition of all antecedent effective rainfall.

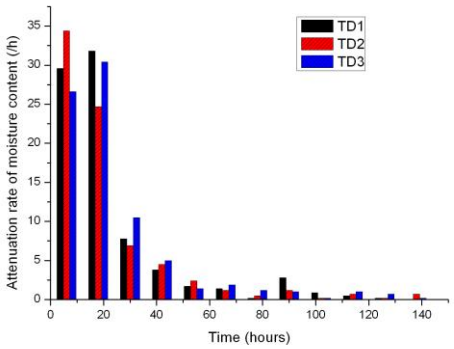

Fig. 1 The attenuation rate distribution of moisture content of three testing points

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Selection of ground motion prediction equation by bayesian learning approach

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Abstract

The key in ground motion prediction is to select a suitable and reliable GMPE (ground motion prediction equation) applicable to target seismic region (Yuen and Mu, 2011; Mu et al., 2014). Significantly level of uncertainty is inevitably involved in the selection process. In the traditional model class selection methods, a set of GMPE candidates is first constructed, then model ranking evaluation is implemented for each GMPE candidate. It is obvious that when the total number of GMPE candidates is huge, computational effort for this kind of discrete evaluation of model ranking is large. In this work, Bayesian learning approach is proposed for addressing this critical computational issue. The key is to embed the ARD (automatic relevance determination) prior (Bishop, 2006; Mu et al., 2016) into Bayesian framework (Beck, 2010), then conduct continuous optimization on the hyperparameter vector, parameterizing the ARD prior, based on the measured ground motion data (Mu and Yuen, 2016). As the relevancy of different terms in the full model class of the GMPE is controlled by the corresponding component of the hyperparameter vector, the optimal model class is automatically determined during the process of continuous optimization on the hyperparameter vector (Mu and Yuen, 2017). Moreover, it can be found that some irrelevant terms in the full model class of the GMPE are automatically pruned out in ground motion prediction.

A database of strong ground motion records in target seismic region is obtained for the analysis. It is shown that the optimal model class by the proposed approach is promising since that, the optimal model class retains both prediction capability and model simplicity.

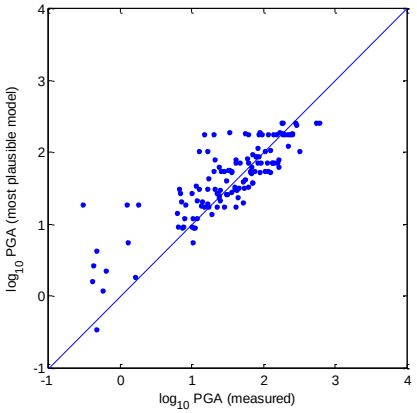

Fig. 1 Prediction by optimal model class Vs. Measurement

Acknowledgments

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A new method for measuring the soil water characteristic function and permeability function of unsaturated soil with filter paper

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Abstract

Water seepage in unsaturated soil can trigger a lot of geo-disasters such as collapse and slope failure. The soil water characteristic function and unsaturated permeability function is the basic parameters to reflect the hydraulic properties of unsaturated soil. However, the determination methods of these two items are cumbersome and time-consuming. For this reason, a small size column-test equipment is designed to simultaneously measuring water characteristic function and unsaturated permeability function based on filter paper method. The equipment consists of two main parts. One is a water supply device which can provide a constant water head by using Mariotte bottle. The other is a soil column setting below the water supply device. The soil column is a group of vertically stacked soil specimens within metal ring which sandwich a filter paper between each two specimens. Along with the water permeate downwards, the water content increases both in the loess sample and filter paper. By weighing the soil specimens and filter paper simultaneously in definite time span, then the water content profiles of both soil specimen and filter paper are obtained. Among them the water content profile of filter paper can be transferred to matric suction profile. Therefore the water content profiles and the correlated matric suction profiles at different times are applied to determine the soil water characteristic function and the permeability function directly by fitting to the profile data. This method is easier to operate and can applied to both remold and intact specimens.

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Landslide susceptibility analysis considering swelling clays

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Abstract

It is well known that swelling clay minerals negatively affect constructions but also produce discontinuities and shear planes on natural slopes, leading to slope instability as well as shallow landslides.

The aim of this study is to evaluate landslide susceptibility using hyperspectral remote sensing technology which has the potential for direct identification of constituent minerals in soils (Sabine et al., 2002). Spectroradiometic results of ASTER (advanced spaceborne thermal emission and reflection radiometer) satellite imageries similarly corresponded to the distribution properties of expandable minerals which were obtained from field investigation and mineral analyses by XRD and XRF.

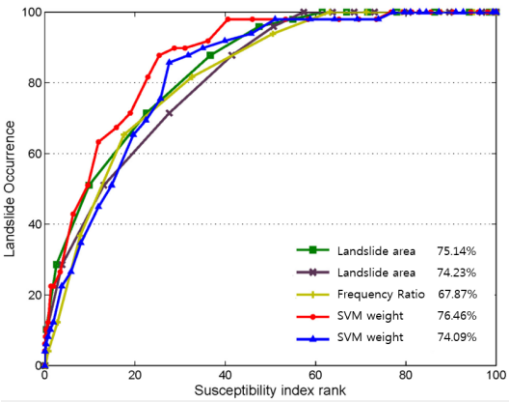

Fig. 1 Success rate curve for the landslide susceptibility maps.

The landslide susceptibility map was constructed through factor correlation using statistical analysis by SVM (support vector machine) to analyze the spatial database.

Comparison of success rate curve values showed that using the illite index model provided landslide susceptibility maps that were 76.46% accurate, which compared favorably with 74.09% accuracy achieved without them (Fig. 1) (Nam et al., 2016).

Acknowledgments

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Mechanical properties of sands subjected to local particle loss

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Abstract

Loss of soil particles due to mineral dissolution, degradation or internal erosion can lead to a change in the microstructure of soil, which as a result, affects the strength and stiffness of soil. In previous studies, sand-salt mixtures were commonly used to trigger particle loss. Those findings regarding the strength and deformation behavior of soils were mainly based on the assumption that the internal volumetric strains caused by particle dissolution follow a random spatial distribution (Fam et al., 2002; Truong et al., 2010; Kelly D and McDougall J., 2012). However, for soils subjected to local disturbance such as subsurface cavity or piping, nonhomogeneous fabric would be generated characterized by concentrated discontinuous macropores. To our knowledge, there have been no recent studies on the mechanical properties of soil subject to such local particle removal.

In this study, with the aim to reproduce internal erosion in the form of cavity and piping, particle loss was induced by saturating specimens with glucose, shaped in block/pipe with certain volume. The influence of amount and form of particle loss on the mechanical properties of soil, both in terms of large and small strain was investigated.

A series of triaxial compression tests were conducted on the controlled artificial specimens under different confining pressures. Changes in overall volume and void ratio during dissolution were obtained by local sensors. Small strain stiffness properties were investigated by applying small cyclic loadings.

Based on the results, it was found that particle loss led to an increase in void ratio, which was sensitive to the amount of dissolved particles. Despite of the limited degradation in shear strength for soil at post-dissolution state, marked reduction in small strain stiffness was observed, indicating the fabric changes in the assembly of particles. In addition, different failure behaviors were observed in specimens with glucose in different shape. In those tests simulating ground cavity by glucose block, sudden collapse in shear strength was perceived in dense sand and nearly 26% strength reduction occurred. In the specimen subjected to piping erosion by means of dissolving glucose pipes, the overall strength was not significantly influenced.

Acknowledgments

This work was financially supported by the National Natural Science Foundation of China (Grant No. 51609171).

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Effect of drying-wetting cycles on aggregate breakdown for yellow-brown earths in karst areas

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Abstract

Background: Due to the severer interference of human activities on global climate, extreme climate scenarios like drought and rainstorm has occurred frequently in recent years, causing higher risk on the control of karst rocky desertification. Extreme and frequent climate change, expressed by drying-wetting cycles, makes the breakdown of typical yellow-brown earths composed of water-stable and water-unstable aggregates to be thorougher.

Research goals: The main objectives of the research are to further our understanding on the impact of the drying-wetting cycles and initial water content on the breakdown of water-stable aggregates; to qualitatively demonstrate how the slaking behaviors develop and how the size distributions of water-stable aggregates varies; to establish the mathmatical model for assessing the relative leakage ratio of soils.

Methods: Two identical series of specimens are subjected to drying-wetting cycles and wet sieving. Series I are the samples with the field-moist content in five replicates subjected to successive cycles corresponding to an alternation of oven drying and immersed wetting. Series II are the samples with varied initial water contents affected by the same drying-wetting cycles. The masses of the water-stable aggregates in each size range after wet sieving are monitored.

Results: (1) The results show that the water stability of soil aggregates are weakened by the further drying-wetting cycles: the alternation of drying and wetting conditions leads to the gradual division and refinement of larger water-stable aggregates and reunion of smaller ones. The aggregates in the diameter of 1-2 mm are in the dynamic equilibrium state between the two reverse processes; Except for the first cycle, the gradation of aggregates will not change obviously. (2) In addition, It is found that the greater initial water content strengths the water stability: there exists a critical water content (about 27%), less than which the soils are predominantly composed by smaller aggregates; otherwise the soils are predominated by the medium aggregates; The existence of a turning point in the diameter of 0.3 mm makes the variation laws of the water-stable aggregates with the increase of initial water content thoroughly opposite. (3) The mathmatical model for the relative leakage ratio based on the drying-wetting cycle, initial water content and size distribution are established.

Conclusions: The findings reported in this paper may be capable of assessing the leakage risks under the influence of climate change.

Keywords: Drying-wetting cycles, yellow-brown earths, water stability, aggregate breakdown, leakage ratio

Subsidence cause investigation on the Shinjiko embankment by microtremor chain array survey

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Abstract

Sinjiko lake embankment in the Izumo region of Shimane prefecture is a major structure protecting the eastern side of Izumo city from flooding disaster. Currently in some parts, there is remarkable subsidence in the embankment after its construction.

Microtremor chain array method has been applied to clarify the cause of subsidence. It is one of the geophysical investigations, which is non-destructive and portable, and convenient under different geological conditions. It can estimate the subsurface structure of ground by extracting surface waves from underground micromotion (Mitani et al. 2012).

For this study, survey was carried out in two different parts of the embankment, i.e., Cement Factory site and Gobbius site. In the Cement Factory site, there are some problems with ground subsidence. The microtremor chain array result shows that the top surface at the site is hard, where phase velocity is about up to 130m/s. Below this surface layer there is a thick soft layer, and the phase velocity is as low as about 30m/s (Fig. 1). In the Gobbius site, there, hard layer mainly distributed, only with a few soft zones extending vertically with average phase velocity of 140m/s. Phase velocity profile for cross section of Gobbius site shows presence of soft layer in some chunk with phase velocity about 50m/s.

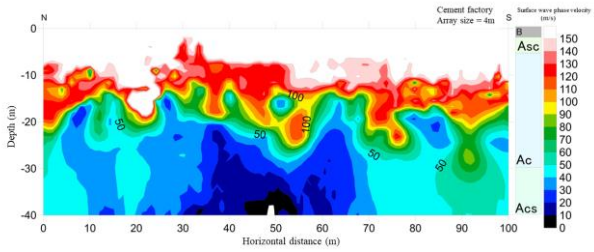

Fig. 1 Phase velocity profiles for the Cement Factory site embankment. Array size = 4m.

Acknowledgments

This work was finiancially supported by Izumo River Office of the Ministry of Land, Infrastructure and Transport, Japan.

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Research on the influence of seepage on the unsaturated landslide dam

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Abstract

Due to rapid deposit of soil and rock materials, landslide dams are normally loose in structure, week in cementation and lack consolidation. Therefore, seepage has influence on the stability of landslide dams. Since materials of the landslide dams are mostly unsaturated, analyzing the influence of seepage on the landslide dams should take the unsaturated soil theory into consideration.

In this paper, firstly, the constitutive model of unsaturated soil is selected and its rationality is verified. Then, based on the water retention test of the landslide dam material, the parameters of unsaturated soil constitutive model are obtained. Finally, these parameters are used to do numerical calculation of landslide dam model tests. Comparing the results of the model tests and simulation, the influence of seepage on the unsaturated landslide dam is discussed.

The influence of seepage on the landslide dam differs from the difference of dam materials. Under seepage condition, the increasing of the saturation and the reduction of downstream slope effective stress leads to slide of fine grain landslide dam; the height decreasing of continuous graded landslide dam would advance the dam breaching; the piping channel could form and cause the failure of gap-graded landslide dam. With the increasing of upstream water level and material saturation, the local volumetric strain of gap-graded landslide dam (Fig. 1) and the horizontal cracks form, which develop into the piping channel.

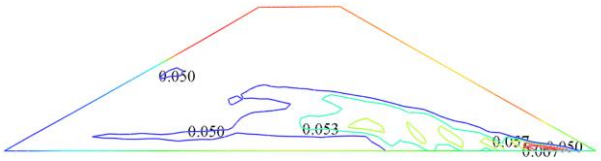

Fig. 1 Volumetric strain of gap-graded landslide dam

Acknowledgments

This work was supported by Natural Science Foundation of China, Grant No. 41372272, 41402257 and Shanghai Science and Technology Talent Project, Grant No. 14YF1403800.

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A model coupled with artificial neural network (ANN) for assessment of susceptibility to earthquake-induced landslides

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Abstract

A landslide susceptibility map can display the likelihood that landslides will occur in a given area, which is a useful tool in disaster prevention and mitigation (Ermini et al., 2005). Therefore, it is important to access the landslide susceptibility and prepare relevant maps after establishing the coseismic landslide inventory (Xu et al., 2014a; Xu 2015). Among many soft computing methods, the high abilities of handling and forecasting complicated problems make the artificial neural network (ANN) method often be used for landslide susceptibility assessment (Yilmaz., 2010; Xu et al., 2016). Landslides triggered by earthquakes are widely distributed, destructive, instantaneous and usually without warning (Keefer, 1984; Xu et al., 2014a; Xu et al., 2017).

The Mw 5.9 earthquake occurred on 22 July, 2013 in Minxian, Gansu, China, triggered thousands of landslides (Xu et al., 2014b). According to the latest research (Tian et al., 2016), there are at least 6,479 coseismic landslides triggered by this event in the seismic area of 873.95 km^2. Ten control factors, including elevation, slope, slope aspect, curvature, slope position, the distance to drainages, lithology, earthquake intensity, peak ground acceleration and the distance to the causative fault, were considered in assessment of the landslide susceptibility in the study area. First of all, the total landslides were divided into two sets: training dataset (4,536, accounting for 70%) and validation dataset (1,943, accounting for 30%). The equivalent non-landslide points of training and validation datasets were randomly selected outside the 5m-buffer areas of these coseismic landslides. Then, 9,072 points were employed to train the ANN model and 3,886 points to validate the model. The success and predictive rates of the ANN model are 90.8% and 87.4%, respectively (Figure 1).

The results show that there are 5,570 (86% of the total) landslides are distributed in the high and very high categories of the landslide susceptibility map (Figure 2), which means the predicted result of this model is highly consistent with the actual distribution of landslides in the Minxian earthquake region. Moreover, this is a successful example indicating that the ANN model is a preferable tool for susceptibility assessment of earthquake-induced landslides, especially in those regions similar to the study area of this work.

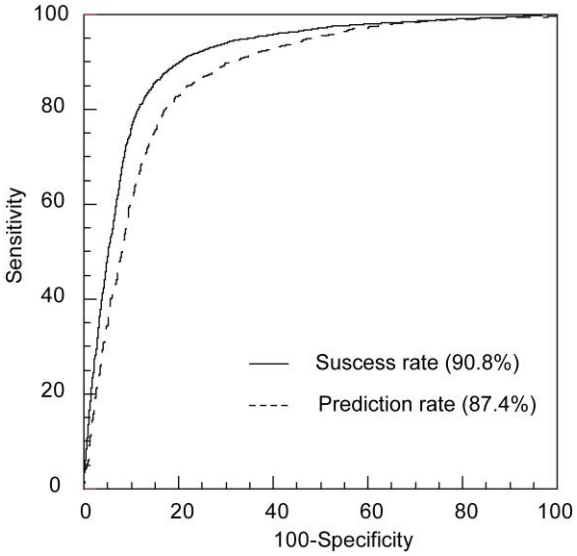

Fig.1 Success and prediction curves for the ANN model.

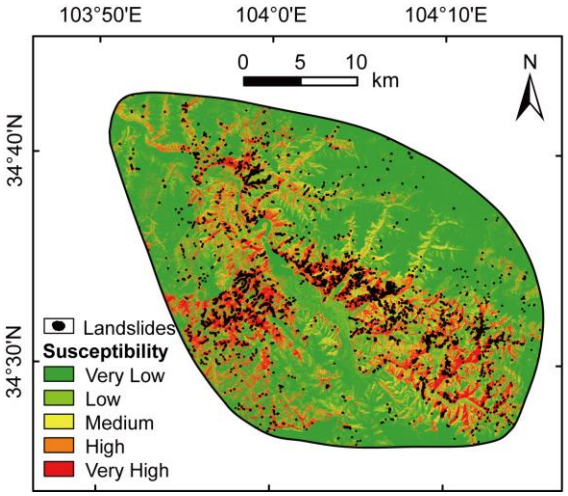

Fig. 2 Landslide susceptibility map of the 2013 Minxian earthquake

Acknowledgments

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Analysing post-earthquake landslide activity using multi-temporal landslide inventories near the epicentral area of the 2008 Wenchuan earthquake

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Abstract

Large earthquakes in mountainous regions may trigger thousands of landslides, of which a part continues to be active for a number of years, depending on the frequency and intensity of rainfall events in the years following the earthquake. Such rainfall events may reactivate co-seismic landslides and trigger debris flows that impact on reconstructed settlements and infrastructure. The uncertainty with respect to post-earthquake landslide activity makes the reconstruction planning difficult, and more knowledge is required on how geo-environmental systems that have been destabilized due to large earthquakes, go back to a state of equilibrium. In this study we analysed the changes in landslide activity in an area near the epicentre of the 2008 Wenchuan earthquake over a period of 7 years after the earthquake, based on a number of very high resolution remote sensing images. We generated five landslide inventories for different years for the same area through stereoscopic digital visual image interpretation. Our analysis showed that very few landslides were observed in the period prior to the earthquake, and during the earthquake 6727 landslides were triggered covering 29.4 percent of the study area. Landslide activity remained high during the first three years after the earthquake, and new mass movements were mostly in the form of debris flows. Landslide activity in the area dropped considerably in the years after due to the depletion of the available loose materials and vegetation re-growth. Of the total of 6727 co-seismic landslides, 2221 had one or more phases of reactivation after they were triggered by the earthquake until April 2015. The most frequent post-earthquake landslide type is flow, accounting for 66% of all the active mass movements in the post-earthquake inventories. After the earthquake in 2008 until April 2015 a total of 660 new landslides occurred, outside of the co-seismic landslide areas. In April 2015, the number of active landslides had gone down to 66, which was less than 1% of the co-seismic landslides, however, it was still much higher compared with the pre-earthquake situation. Based on our findings we expect that the landslide activity will continue decaying in the area. However, this trend may be halted if extreme rainfall events take place in the coming years, as the remaining loose materials are still able to generate major landslide events.

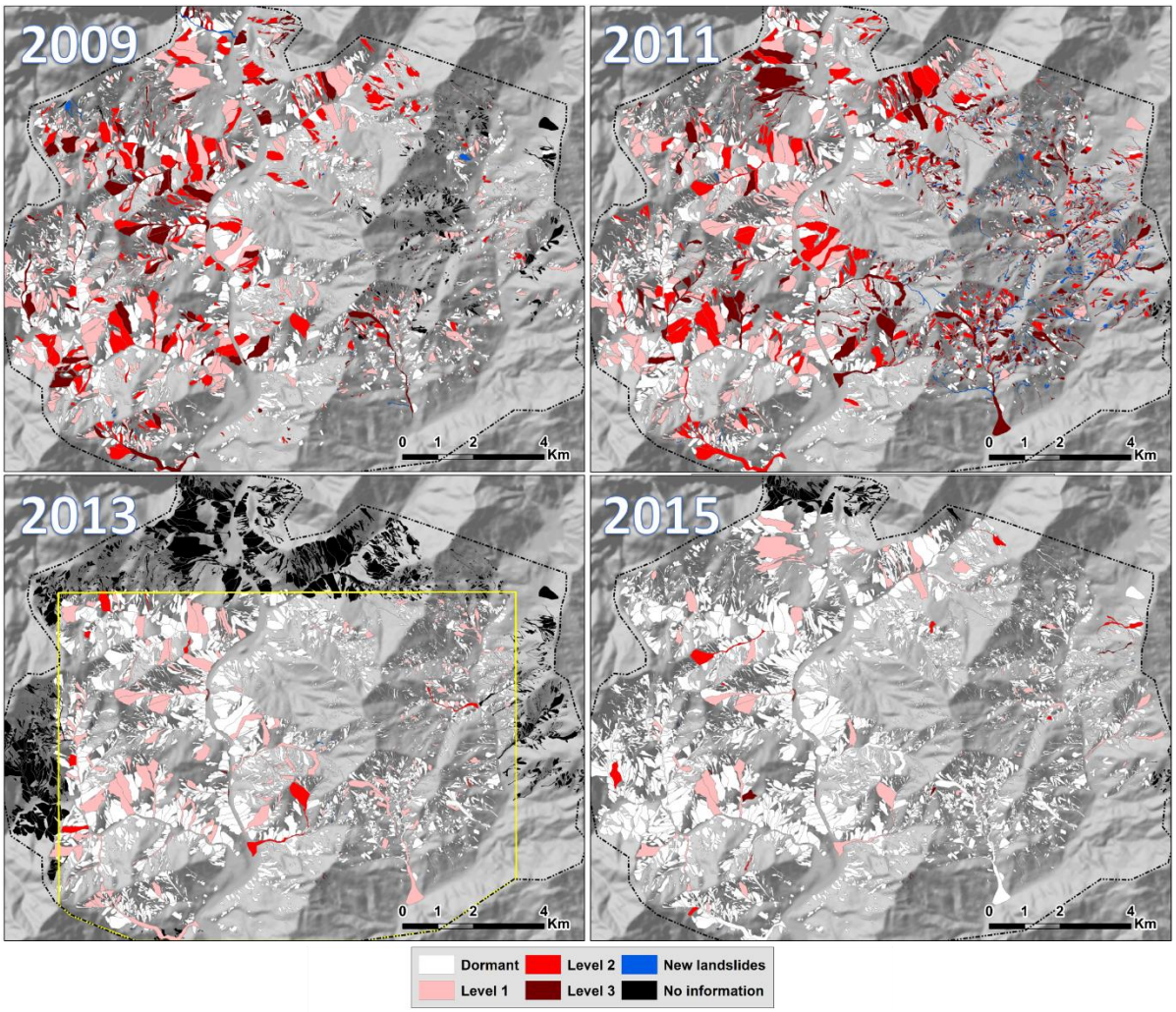

Fig.1 the post-earthquake landslide inventories

Keywords: multi-temporal; landslide inventories; post-earthquake landslides; Wenchuan earthquake; image interpretation;

Research on the prediction method of starting water content of natural loess landslide

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Abstract

As one of the most common geological disasters in loess area, the great threat and huge loess to people's lives and property are taken by the loess landslide. However, the prediction of the loess landslide is still a popular and difficult topic in landslide research due to its wide range of distribution, high cost of monitoring system, and immature prediction methods. Because the essence of loess landslide formation is the deformation and failure process of slip zone soils, start-up conditions of landslide could be predicted by the variation characteristics of physical and mechanical parameters of slip zone soils. In this paper, Zhengcheng landslide in Shanxi province is taken as the research object, shear strength parameters of slip zone soils are obtained by consolidated undrained triaxial experiments under different water contents, and the relationship between strength parameters and water content is established with reference to other areas of the similar loess shear strength parameters. Then, the process of infiltration of water along the slip zone is simulated by finite element method software, the water content change regulation of all micro elements are obtained, the distribution of water content are calculated when the value of shear strength of slip zone soils is equal to the mobilized shear strength combined with the relationship between water content and shear strength by triaxial tests, then the critical occupancy of slip zone soils that the water content reaches the plastic limit is obtained when the landslide occurred, and the goal of the prediction of landslide through the water content can be achieved ultimately.

SPH simulation for entire process of Tangjiashan landslide under the action of earthquake

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Abstract

Tangjiashan landslide triggered by Wenchuan earthquake is one of the most impressive landslides. The entire process of Tangjiashan landslide contains three stages: initiation process, high-speed movement and deposition. To better understand the dynamic evolution rule of Tangjiashan landslide, more attention should be paid to the entire process of landslide under the action of seismic shaking.

The paper adopts the smoothed particle hydrodynamics (SPH) method to simulate the entire process of Tangjiashan slope. Following the framework of SPH method based on solid mechanics, the Drucker-Prager model with non-associated plastic flow rule is employed in the SPH. Seismic wave is applied to the bottom boundary particles through the format of velocity and the bottom boundary is set as no-slip boundary. Meanwhile, free field boundary is chosen to reduce the reflection of seismic wave.

One benchmark problem, oscillation of the thin plate, is simulated and validated by comparing the analytic solution with the simulation results. Then Tangjiashan slope deformation triggered by earthquake loading is simulated and analyzed. The formation process of slip surface in the initiation process is clearly captured by SPH simulation. At about 33 s, a maximum velocity of 23 m/s has been reached. After 50 s, the landslide mass deposits in the valley between slopes.

Acknowledgments

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Monitoring and mitigation plan of rainfall induced landslide creep movement of Cimanuk River Dam, Sumedang, Indonesia

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Abstract

The creep movement on the upstream side of Cimanuk River dam has set a concern that it would affect the dam stability. Some bore piles reinforcement which had been installed with lack investigation and monitoring data fails to stop the movement. To improve the mitigation, a monitoring system has been implemented. The monitoring system consisted of real-time GPS surface movement sensors, inclinometers, and hourly rainfall gauge. Additional data of bore log and SPT test were also provided.

The rainfall and movement velocity were then observed to understand the mechanism of the landslide. Numerical analyses were also conducted to study the effect of the movement to the stability of the dam.

The bore log shows that the moving deposits consists of highly decomposed breccia tuff. The data taken from February 2016 to November 2016 showed strong relation between movement vector and rainfall intensity. Whereas, the results of numerical analysis will be presented in the forum.

Acknowledgments

This work was supported by the Dam Construction Work Unit of Cimanuk – Cisanggarung River Catchment Area Office, by providing valuable monitoring data from rainfall and inclinometer records.

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Landscape hazards in danxia landform of Kongtong Mountain

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Abstract

Kongtong Mountain is located in the southwest of Ordos Basin, also is the transition zone of Longdong Loess Plateau and Liupanshan Mountains, Danxia landform develops on its thick continental deposited Triassic and Cretaceous conglomerate. Many strange shaped unstable rocks occurred in the Danxia landform areas, not only do they have great ornamental and aesthetic value as tourists' attractions, but also are potential disasters. Through investigation on an amount of 91 original and potential landscapes of unstable rocks, 82 unstable rocks is found in Sanqiao group (K_1s), while the total amount of unstable rocks of Permian, Triassic and Heshangpu group (K_1h) of Cretaceous is only 9. The complicated geological environment makes the main scenic spots of high risk, so the protection and management of unstable rocks is very important to the development of the geopark, but it is also a big challenge due to the high technical difficulty, and we should take necessary measures to protect the landscapes and prevent potential disasters. Therefore, it is very necessary to conduct some investigations on the properties of conglomerate. We use geographic information system (GIS) to extract the spatial and morphologic features of Danxia Landform, combined with geochemistry methods such as ICP-MS (Inductively coupled plasma mass spectrometry), polarizing microscope analysis and XRD (X-ray diffraction) to look into the element and mineral compositions of the conglomerate. The preliminary result reveals that the corrosion of calcareous cement such as calcite, ankerite and dolomite is very important to the formation process. Differential weathering, water erosion, biological deposition, freezing thawing and chemical element migration are contributed to the fantastic shapes during the formation process of the rock landscapes. While human activities, earthquake, gravity unloading and root splitting are the major reasons for the failures.

Acknowledgments

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Geological tectonic control on the landslide of the West open-pit mine in Fushun city, China

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Abstract

Coal mining and excavation at the West Open-Pit Mine, Fushun, China, has resulted in a slope of up to 400 m in height that is sliding at a rate of ca. 100–200 mm/day. This landslide is located in the downtown area in Fushun city, which not only affects the coal mining operations but also the daily life of the surrounding people and the production potential of more than 20 local enterprises. Field investigations of the geological conditions of the southern slope of the West Open-Pit Mine were undertaken to determine whether the formation and development of the landslide is controlled by the geological conditions. Monitoring of strata movement and mineral composition tests were performed to support this work. The results showed that the landslide is large, complex, and deep-seated. It is considered to be a complex landslide and is controlled by two slip surfaces. The landslide has a deep and a shallow slip surface that are controlled by the geological stratification and that terminate in a series of faults. Faults both determine the boundary of the landslide and affect the stress regime, which has led to the formation of the two slip surfaces and a measurable change in the landslide slip velocity and orientation.

Acknowledgments

This project was financially supported by the National Natural Science Foundation of China (Grant NO.41572254, Grant No. 41172235) and the Basic Research Foundation of Jilin University (Grant No. 450060491447).

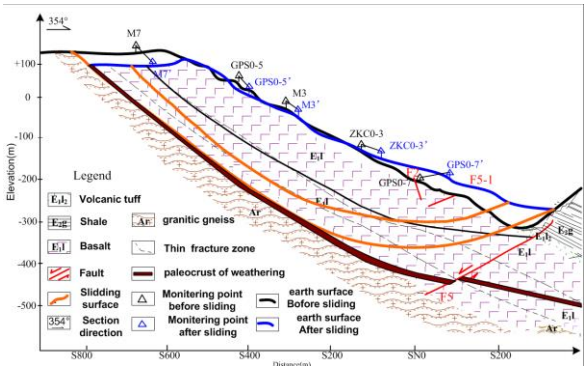

Fig. 1 Diagrammatic cross-section along line E1200 in the West Open-Pit Mine

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The rubber protective structure design of shed tunnel and its buffer mechanism research under impact load

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Abstract

As one of the most commonly used protective structures against rock fall in mountain area, the shed tunnel has been studied by many geological hazards researchers. Generally, the typical shed tunnel structure consists of two parts: reinforced concrete frame and a cushion material (gravel or clay material) covered with a certain thickness on the top. The selection of cushion material has an important effect on the safe use of the shed tunnel. In this paper, we designed a lightweight prefabricated cushion layer: it is mainly composed of prefabricated rubber block (PRB), the rubber block is connected by rubber bolts (RB) to form a cushion layer, then use the embedded bolt to fix the cushion layer on the shed tunnel roof to dissipate the energy of rock fall hitting on the top of reinforced concrete frame. Rubber blocks are produced by ordinary rubber, its ultimate compressive strength and tensile strength should not be less than 90MPa and 150MPa, compression permanent deformation and resilience should be more than good level. In addition, in order to meet the practical engineering requirements, two sizes of rubber blocks (25cm, 50cm width) are designed. Dynamic response of rock fall impacting the shed with rubber cushion structure was analyzed by dynamic finite element method to explore the reasonable thickness of rubber block. The results indicated that the thickness of PRB should not be less than 50cm when rock fall (0.5m radius) impact the rubber cushion with speed 20m/s. The impact energy is dissipated directly by rubber cushion layer. Comparing with traditional rock-shed (covered in soil or gravel), the shed tunnel covered with rubber cushion can reduce self-gravity loading, impacting force, concrete slab displacement, and stress response of the shed structure, therefore has a vast prospect in engineering application.

Keyword: Shed tunnel, Rock fall, Rubber cushion structure, Dynamic finite element.

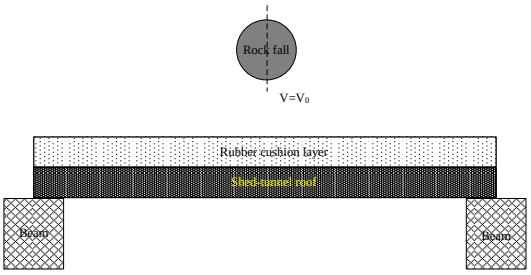

Fig. 1 Calculation model of rock fall impact shed-tunnel rubber cushion layer.

Acknowledgments

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Seismic responses of deep buried pipeline under non-uniform excitations from large scale shaking table test

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Abstract

The seismic response of long deep buried pipeline under non-uniform excitation is very important for suitable seismic design. However, due to restricted by excitation devices, few model tests have been carried out. In this study, a large-scale shaking table model test for a long deep buried pipeline was carried out, where two controlled-independent tables were used to excite two model containers and the excitations for the two tables are in the three directions and non-uniform. From the model test, the bending and torsional deformations of the pipeline under non-uniform three-dimensional excitations were especially measured and evaluated while they were ignored in general. Some results were achieved: (1) the bending stain and permanent displacement under uniform excitation are negligible, but not neglected for non-uniform excitation; (2) the model test proves that there is obvious rotation of the pipeline except horizontal and vertical displacements under non-uniform excitation.

Acknowledgments

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Formation mechanism of large landslides triggered by earthquakes in Tianshui Loess hilly region

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Abstract

Strong earthquakes frequently struck Chinese loess hilly region, and earthquake-triggered landslides are the main reasons for severe casualties and property losses after the main shock. The 1718 great Tongwei earthquake in northwest China, resulted in more than 300 large-scaled landslides near the epicenter and total burial of Yongning town (Pan'an Town) with a historical record of over 30,000 deaths. The study aims to reveal the distribution characteristics, failure mode and formation mechanism of large landslides induced by strong earthquake on the basis of field investigation, experimental analysis and FLAC^{3D} numerical simulation. Field investigation is indicative of the fact that topography affected distribution of landslides significantly: on the north bank of Weihe River which belongs to loess hilly region, landslides were intensely developed; on the south bank of Weihe River, which is close to mountainous terrain, landslides were relatively less and avalanches and debris flows were developed. The results of FLAC^{3D} numerical simulation indicates the possible process of a typical loess-mudstone complex landslides (Fig. 1). The targeted landslide is inclined to unstably slide along loess vertical joints and weak structural surfaces of the underlying mudstone at the foot of slopes. Then, shear failure occurs in middle-upper parts of the slope due to the existence of free face and continuous seismic action. And slip surface cuts through the underlying mudstone and the landslide belongs to typical insequent landslide with high speed and long runout. The results of FLAC^{3D} numerical simulation match with field investigation and engineering geologic drilling. In addition, loess-mudstone complex landslides with smooth slope after high-speed and long-runout sliding are basically stable in natural state, but they have high possibility to unstably slide and develop to loess-mudstone interface landslides, especially under strong earthquake.

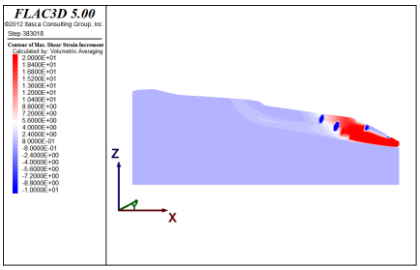

Fig. 1 Max shear stain increment of slope before earthquake

Acknowledgments

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A laboratory study of the correlation between electrical resistivity and matric suction of the loess

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Abstract

The loess is a silt-rich, aeolian soil that is widely distributed in the northwest China. Loess landforms are particularly prone to natural hazards, such as ground subsidence and landslides. During the soil parameters, the matric suction is a key factor influencing the strength and stability of loess. In field, the most common methods for measuring the matric suction are probe measurements, which can provide accurate local information about the matric suction. However, It is costly to evaluate the spatial distribution of the matric suction.

Electrical resistivity tomography (ERT) can image the temporal and spatial resistivity distribution using a large number of four-electrode measurements. In the partially saturated loess, like the matric suction, the electrical resistivity of soil is mainly affected by the water content. Hence, ERT could be a promising method for the estimation of matric suction of loess. The objective of the present study is to assess the relationship between the electrical resistivity and matric suction of loess in laboratory.

In the paper, the laboratory analyses were first conducted to defining both the matric suction and electrical resistivity curves versus water content. The matric suction was measured using filter paper (Whatman, no. 42), and the soil resistivity was measured using the Wenner four-electrode method. Based on the van Genuchten model and Archie's law, the relationship between the matric suction and electrical resistivity was then discussed. In addition, a PVC column with a height of 50 cm and a diameter of 24 cm was filled with the loess, and an experiment involving artificial rainfall was conducted. The variations in water content, matric suction, and electrical resistivity were measured simultaneously.

The results show that the soil electrical resistivity is proportional to the matric suction of loess and a fitting formula was established. In the column experiment, there was a clear positive relationship between the electrical resistivity and matric suction in the lower part of loess column.

Acknowledgments

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Study on tsunami-resistance of a reinforced soil wall based on water tank experiment.

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Abstract

The 2011 off the pacific coast of Tohoku earthquake (Mw=9.0) caused great damage of geotechnical structures in the vicinity of the eastern coasts. In contrast, many of reinforced soil walls constructed along the coast were less damaged by the tsunami. In this study, we conducted a model test using water tank to evaluate the behavior of a reinforced soil wall under strong water flow and water pressure like tsunami.

To simulate the strong water flow of tsunami, we developed a water flow device in a water tank. Fig. 1 shows the schematic of the device. The scale of model is 1/40, the height of wall is 25cm and the water level is 20cm, supposing that a tsunami hit the wall whose height is 10m in a full-scale without overflowing. The wall consists of front panels, crashed stone as drainage materials, and granite soil as backfill soil. Some geogrid models put between the backfill soil, and front panels are connected backfill soil with grid belts. Water flow hit the wall keeping its velocity and level. When the water penetrate into the backfill soil until ground water level is same as the level of water flow, we stop hitting water to the wall, and drain the water out of the tank, supposing a drawback of tsunami.

We conducted 2 test cases. One is a non-damaged wall, and the other is a wall with some opening of the front panels which simulates the gap of the wall due to residual settlement after an earthquake.

As a result, we found that a reinforced soil wall does not have large deformation unless there are some opening of the front panels and the backfill soil flow out of the wall. Our results support that a reinforced soil wall has enough tsunami-resistance and it is necessary to prevent a settlement of the wall.

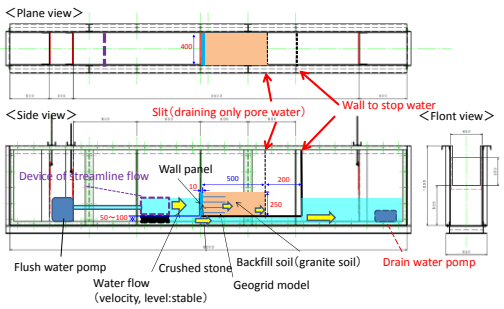

Fig. 1 Schematic of the water tank experiment device

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Fast shear behavior of saturated and dry Loess at South Plateau Landslide of Jingyang, Shanxi

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Abstract

Experimental studies were conducted on fast shear conditions of saturated and dry loess at south Jingyang Plateau Landslide, Shanxi by employing ring shear apparatus. Test results indicate that:(1)Compared with the dry state loess, the loess under saturated conditions significantly reduce the shear strength index under the same test conditions.(2)The saturated with the dry loess retrieved from south of Jingyang have shown strain softening characteristics in quick succession shear conditions, but saturated loess is more significant softening characteristics than the dried loess.(3)Under the same conditions of normal stress, shear rate has significant influence to peak intensity for drying and saturated loess, but the peak strength of the soil in pace with the shear velocity variation is different under the two states. Saturated loess peak intensity increases with shear rate, and dry loess peak intensity decreases with increasing shear rate.(4)In different aqueous state shear mechanical characteristics of loess retrieved from south of Jingyang have different variation of the mechanism. Among them, in a continuous shearing process drying loess shear strength is mainly dominated by clay particles friction (resistance) force, particle alignment and the shear surface morphology. Compared with the dry loess, the peak shear strength of saturated loess soil is mainly affected by changes in the cohesion of control; Effect of soil water in the body can exacerbate their degree of strain softening and form shear smooth surface morphology, thereby affecting its peak after the shear stress.

Key words: ring shear；shear strength；shear rate；strain softening；peak intensity；residual strength

Landslide movement mechanism analysis using LiDAR technique through point cloud change detection

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Abstract

Landslides are mass movement of rocks or soils induced by some factors unexpectedly and instantaneously. In the period of 2004-2010, 32,322 people were killed in landslides all over the world, of which 6,866 fatalities occurred in China (Petley 2012). Deformation monitoring and analysis contribute to understanding the movement mechanism and play key role in early-warning system of landslide. In recent years, capable of acquiring three-dimensional information of the terrain with high accuracy and high spatial resolution, Light Detection and Ranging (LiDAR) technique is exponentially developing in landslides investigation.

This paper confirms to adopt the point cloud change detection method, by LiDAR technique, to establish the surface displacement field of a giant landslide in China. And to further understand the deforming rules, four sections have been set up on the slope horizontally and vertically. Having compared the changing tendency of different regions, some basic features of slide movement are revealed which thereby provides instructive suggestions in measurement enhancing and disaster warning of landslide.

Acknowledgments

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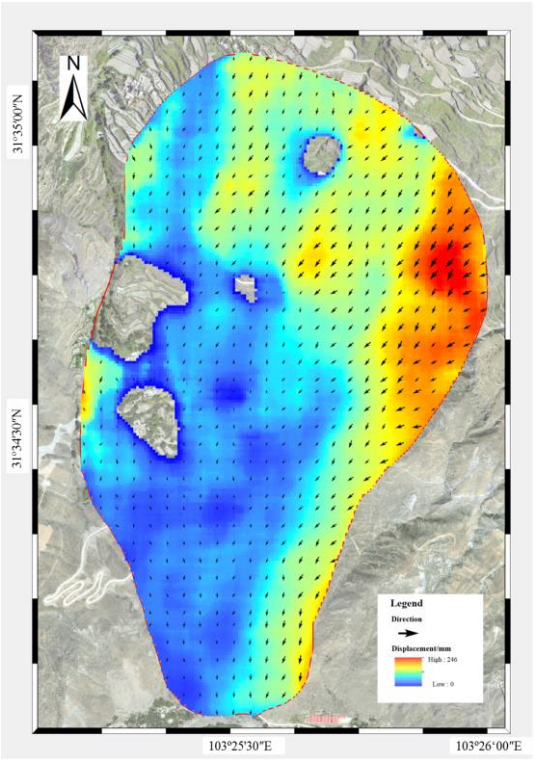

Fig.1 Annual landslide surface displacement field

Poster Session

Failure mechanism and post-disaster effect of Weijiashan landslide induced by Wenchuan earthquake

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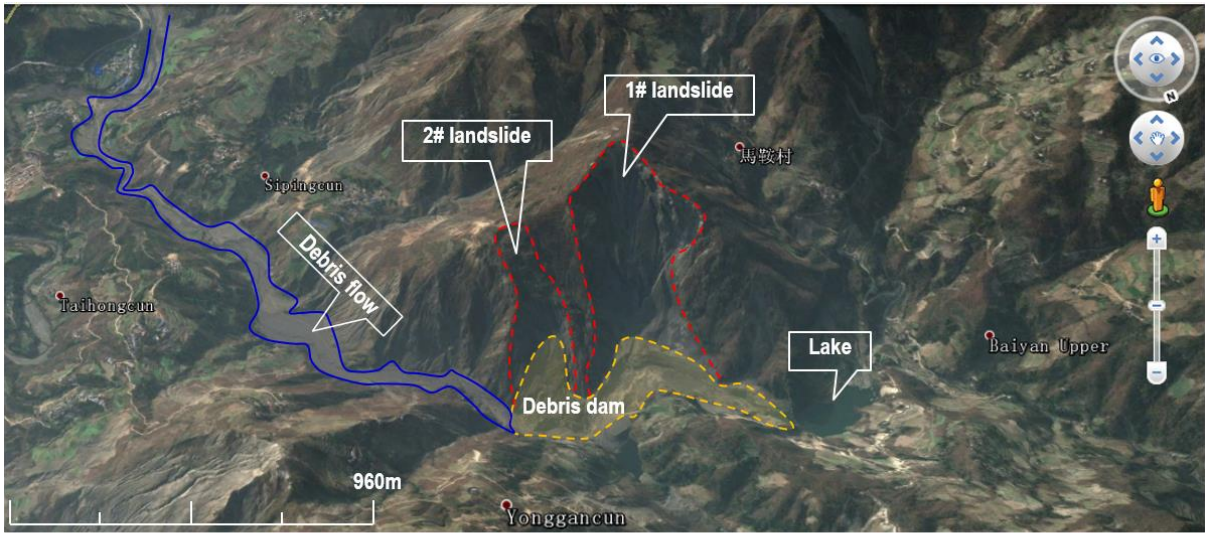
Abstract

Wenchuan earthquake induced thousands of landslides (), and this produced large amounts of loose solid materials (landslide debris). This loose material creates an important hazard as strong rainfall can cause the development of devastating debris flows that will endanger the resettled population and destroy the result of reconstruction efforts (Tang et al. 2011; Huang X. & Tang C. 2014; Hu T. & Huang R.Q. 2017).

The Weijiashan landslide, which is also induced by Wenchuan earthquake, consists of two separated landslides (1# and 2#) (Fig.1(a)). The two landslide had a volume of about $1.15\times10^7 m^3$, killed 25 people and destroyed houses on the slopes at the time of landslide occurred. Moreover, huge debris covered farmland, houses and blocked the river. According to filed investigation, debris flow happened in every rainy season.

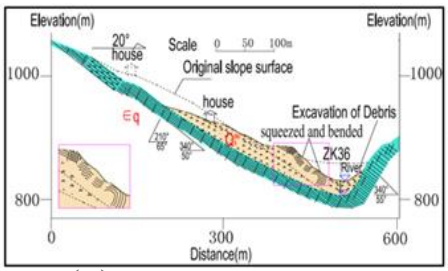
Geological analysis and Discrete Element Method (UDEC) were used to study the failure mechanism of the two landslide. For the two landslides, failure mechanisms are same. Seismic action firstly shaped a deep large fissure along bedding planes, which was parallel to the steep-dip slope surface on the back of the slope. And then the bottom of the pull-apart rock mass engendered shearing glide. But the two landslides present different accumulation characteristics. For the 1# landslide, most of accumulation is crushed stone and gravelly soil. The landslide slides from top to bottom and accumulated in the river. And the top surface of accumulation is flat (Fig.1(d)). For the 2# landslide, most of accumulation is large blocks and still keeps layer structure. Orientations of blocks are varied from trailing edge to leading edge, which pointed out that the accumulation of 2# landslide were squeezed and layers were bended. And the top surface of accumulation has low dip angle (Fig.1(c)). This means that the 1# landslide had a quick speed when it happened. Because of long distance and fast sliding, when the accumulation arrived the river bottom, it was shocked and collapsed, and climbed to the other side. But for the 2# landslide, because of lower position and narrow river channel, the whole sliding body only slid very short distance and then the front of the body were blocked by the steep bank slope of the other side. So the collapse of the accumulation was inadequate. And the accumulation was squeezed and bended.

The loose debris, with more than 50m depth, increased greatly the volume of loose source materials available to be mobilized by debris flows. As the material is particularly loose, even very small rainfall can bring debris to form flows. In the downstream, many houses, with low elevation along the river, were buried by the debris flow. And from longitudinal section, layered property is obvious. Considering the catastrophe of debris flows, engineering measures should be carried out.

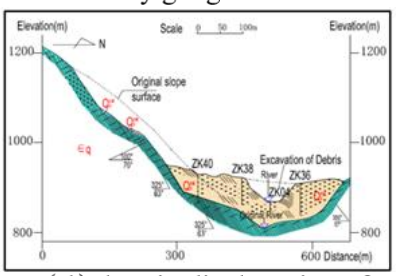


（a）spatial distribution of landslides, debris dam, lake and debris flow by google earth

（b）houses in the gully were buried by debris flow



（c）longitudinal section of 1# landslide



（d）longitudinal section of 2# landslide

Fig.1 Failure mechanism of earthquake-triggered landslides and post-disaster effect

Acknowledgments

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Technical problems in urban earthquake disaster mitigation planning

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Abstract

Earthquake prevention and mitigation is one of the key points for disaster prevention and mitigation project in China. Urban earthquake disaster mitigation planning(UEDMP) began in the late 1970s. In view of huge loss of Wenchuan earthquake in 2008, China's government at all levels have launched many new UEDMP projects. Based on the research results of earthquake disaster mitigation planning in United States, Japan and China, every part of UEDMP is analyzed in this paper and the key technical problems are summarized. This paper also discuss importance, technical difficulties, operability and specific operation methods for UEDMP, and gives some solutions and recommendations.

Hazard assessment of debris flows in the Wenchuan earthquake-stricken area, South West China

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Abstract

In order to analyze the changes landslides after the Wenchuan earthquake and after the heavy rain events in the following years, 12 debris flow gullies in the Longchi Dujiangyan County were selected. The Longxi river basin with the city of Dujiangyan, in the Sichuan province of southwest China, belongs to the seismic area of the May 12, 2008 Wenchuan earthquake. Lots of loose co-seismic materials were present on the slopes, which in later years served as source material for rainfall-induced debris flows. A comparison of the TM images taken on 18th September 2007 (before the "5.12"Wenchuan earthquake) with the SPOT5 images taken on 10th February 2009 (after the "5.12"Wenchuan earthquake) indicates that the landslide area in the 12 debris flow watersheds increased from 83.1×103m2 to 3126.5×103m2. The FLO-2D numerical analysis software was adopted to simulate debris flows intensity, including movement velocities and maximum flow depths. A comparison of the measured fan spreading with the simulation results, the evaluation parameter Ω was used to verify accuracy of simulation, the results show Ω values ranging between 1.37 and 1.65 indicating relative good simulation results. This study also estimated the flood hydrograph for various recurrence intervals (20, 100, and 200 years respectively) to perform scenario simulations of debris flows, and followed Swiss and Austrian standards to establish a debris flow hazard classification model on the basis of a combination of the debris flow intensity and the recurrence period. This study distinguishes three hazard classes: low, medium, and high. This proposed approach generated a debris flow hazard distribution map that could be used for disaster prevention in the Wenchuan earthquake-stricken area, southwest China.

Acknowledgments

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Residual deformation in Full-scale shake table test of a gabion retaining wall for road

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Abstract

In Nepal, gabions are used widely as not only river structures typified by river levee but also retaining walls for roads because of its simple construction technique and lower costs. However, many gabion retaining walls were damaged along Araniko Highway after 2015 Nepal Gorkha earthquake (Nakazawa et. al., 2015). In this study, a full-scale model experiment was conducted to estimate an earthquake behavior and a residual deformation of an erect triple layer placing gabion retaining wall which is 3m high as typical gabion structures seen there.

A full-scale model was constructed by packing round stone materials into gabions and filling Masado soil behind the retaining wall in a large soil container. After construction, 4 times shaking tests were conducted by sinusoidal waves of 3Hz with accelerations of 65, 132, 203 and 257Gal. After the case of 132Gal, an expansion of collapsed back fill due to dynamic behavior of the retaining wall was confirmed. In order to estimate the residual deformation, 3D terrestrial laser measurements were conducted after the final shaking. According to the result summarized in Fig.1, 18 degrees inclination of the retaining wall and horizontal displacement of more than 70cm at the crest are confirmed.

As a result, it was found that the gabion retaining wall is relatively flexible, but it doesn't lead to catastrophic destruction.

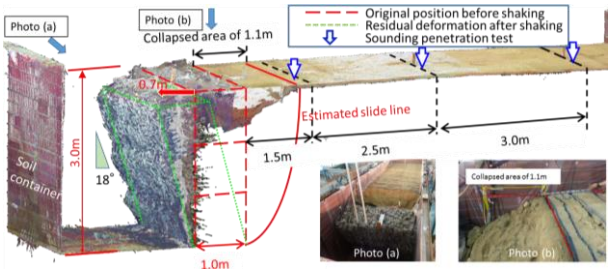

Fig. 1 Bird's eye view obtained from 3D terrestrial laser measurements.

Acknowledgments

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A statistical view of topographic effect on seismic vertical motions of slopes based on a series of shaking table tests

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ABSTRACT

Based on the knowledge of topographic effect revealed by historical earthquakes, especially the 2008 Wenchuan earthquake, a serials of shaking table model tests with two geometric scales (1:100 and 1:22.9) have been conducted using ten model slopes. These models were distinguished by different lithology of slope materials (soft rock, hard rock and their combination) and different slope structures (no structure, horizontal layers and only a weak interlayer) which were commonly developed in the Wenchuan earthquake region. All of them had the slope height of 1.5m~1.6m, the base foundation thickness of 0.2m and the slope angle of 60°. In order to obtain the topographic effect, several three component accelerometers were embedded in different elevations along the slope surface of each model. Vertical component motions were input to excite the models from the bottom of the models, and the input waves were scaled from the Wenchuan earthquake accelerogram (UD component) monitored in the Wolong seismic station. Based on the acceleration measurements, a statistical analysis was then performed on the amplification factor (RPVA) of the peak vertical acceleration (PVA) and the amplification factor (RIa) of the Arias intensity(Ia) for ten model slopes. Results show that, both PVA and Ia demonstrate the topographic amplification effect. However, compared with peak horizontal acceleration responses, PVA and Ia don't demonstrate the obvious topographic amplification in the upper part of each model where the relative elevation h/H exceeds 0.5. On the contrary, PVA also obtains the apparent amplification in the lower part of the slope. For example, as the excitation intensity of input waves is 0.3g, RPVA at the toe ranges from 0.8 to 2.2 while RPVA at the crest is from 1.4 to 5.9. The statistical result of RPVA and RIa of ten model slopes show that, with the increasing elevation, most of RPVA fall in a range of 1.0-4.0, although the maximum RPVA exceeds 9.0 at the crest. At the same time, most of RIa are lower than 8.0. Through averaging the RPVA and RIa of ten slopes at each monitoring point, the tendency of the averages with increasing elevation revealed a three-stage amplification feature, and the amplification rate is largest in the lower part of slope. The statistical results can help better understand the amplification effect of the vertical motions due to slope topography in a quantitative way.

Late-quaternary paleoearthquake and seismic risk analysis of the quanquanzi segment of the fukang fault belt, in Xinjiang

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Abstract

Fukang fault is an important active fault in the Bogeda nappe tectonics in the north rim of North Tianshan Mountain. We discovered that the activity of the Quanquanzi segment of Fukang Fault is distinct during late Quaternary by field investigation of geology and geomorphology ， exeavating trenches along faults and analyzing the age of OSL sample . The trench revealed a total of seven Paleoearthquake events, and the occurrence time of seven events were about (50.48 ± 4.09) ~ (54.11 ± 2.96) ka, (24.09 ± 1.49) ~ (28.21 ± 1.71) ka, (23.22 ± 1.25) ~ (24.09 ± 1.49) ka, (18.88 ± 0.91) ~ (23.22 ± 1.25) ka, (6.24 ± 0.32) ~ (6.88 ± 0.32) ka, (4.64 ± 0.24) ~ (5.54 ± 0.32) ka and (1.90 ± 0.14) ~ (3.47 ± 0.17) ka. Through the occurrence time of Paleoearthquake and fault slip rate method , it shown that Earthquake Average Recurrence Intervals is (1.94 ± 0.47) ~ (2.36 ± 0.14) ka. Through earthquake magnitude empirical relationships and historical seismic magnitude method, we speculate the most potential maximum magnitude is about 7.2 .

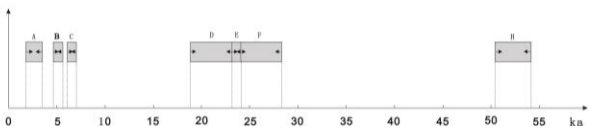

Fig.1 Paleoearthquakes revealed by the trench

Acknowledgments

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Automatic real-time monitoring and early warning system of debris flow in the three major areas of Sichuan province

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Abstract

In this study we summarize some key techniques of automatic real-time monitoring and early warning of debris flow, and presents a solution and a system for real-time monitoring and early warning of debris flow in the Three Major Areas (Yingxiu Town, Qingping Town and Longchi Town) of Sichuan Province. In the aspect of early warning model, we used the other researchers' model of the debris flow in the study area (Yu et al. 2013). Combined with the characteristics of the monitoring data, the specific demand of the warning model, and the criterion of the classification of a rainfall process presented by Jan and Lee (2004), we realize the automatic recognition the rainfall process based on the database technique (Fig. 1). At the same time, the monitoring data are processed at equal time intervals to provide data support for the calculation of the follow-up early warning model.

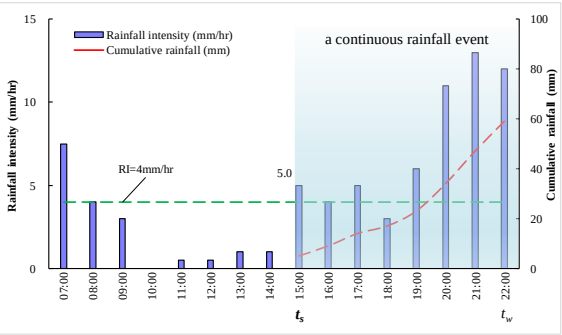

Fig. 1 A continuous rainfall event, RI – Rainfall Intensity.

In the process of early warning, how to achieve early warning process without manual intervention completely automatic, real-time and stable operation, has been the difficult problem of early warning work. This solution introduces the "system service" technology, the entire early warning system as a system-level background Service running on the server, to ensure the stable operation of the whole process of early warning, to achieve a true sense of the automatic real-time process of monitoring and early warning of debris flow. The results of this study are applied to the monitoring and early warning of debris flow in Zoumaling gully in Qingping Town, Mianzhu City, Sichuan Province, which has successfully alerted the debris flow events in July 8, 2013.

Acknowledgments

This work was supported by the Funds for Creative Research Groups of China (Grant No. 41521002).

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Climate change, human impact and hydro-meteorological hazard in Dire Dawa district, Ethiopia

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Abstract

Records of drought in Ethiopia date back to 250 B.C. and since then droughts have been a recurring phenomenon in different parts of the country at different times. Recent studies have shown that the frequency of drought has increased over the past few decades, especially in the lowlands. Drought episodes are commonly followed by food insecurity leading to several casualties and substantial livestock reduction. Climate change prediction will worsen the already severe land degradation and will accelerate deforestation, loss of biodiversity and desertification with negative repercussions on food production and supply. During the last decades, in several parts of Ethiopia, such as the Dire Dawa district, the effects of climate change were paired and exacerbated by deforestation, overgrazing and poor land management. This led to an impressive increase in the frequency of devastating flash floods that repeatedly inundated the town of Dire Dawa, causing several fatalities and relevant property damage. The town of Dire Dawa and its surroundings are therefore experiencing a combination of hydro-meteorological extremes (droughts and floods), the frequency and intensity of which increased in the last decades, substantially limiting the economic development of the area. The occurrence of droughts in the study area was investigated by the Standard Precipitation Index (SPI) and other parameters, such as the aridity index, and a new parameter based on the number of days of rainfall onset delay with respect to the traditional seeding time (Rd). The Recent flood history of the Dechatu R., the main river crossing the city of Dire Dawa, was reconstructed and the effect of recent trends of rainfall intensity and land use change in augmenting the frequency of flash floods was investigated. The result indicate that the risk of drought is consistent and approximately of the same entity for both the small and main rainy seasons, implying negative impacts on livestock and crop productivity. SPI and Rd proved to be reliable methods to predict worrying drought condition in advance, so to alert the farmers and to deploy mitigation countermeasures

The increase in extreme rains, paired by a marked change in land use/cover and management practices are considered the main factor responsible for the increased frequency of devastating floods in Dire Dawa, though the increase in rainfall intensity is likely playing a more relevant role.

An analysis of the reactivation mechanism of ancient landslide

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Abstract

There are many deep valleys in Southwest China, it covers a mass of deposit including residual, slide rock, alluvial and ancient landslide accumulation. Those deposit of ancient landslide with complex geologic structure, the process of deformation—failure—accumulate is complex and changeable when it comes to the dynamic geological process.

The reactivation of old landslide is quite common in Northwest area, many landslides on both sides of rivers have experienced the process of sliding-stable-sliding, and the thickness of landslide body showed changes significantly in space. The reactivation of old landslide relates to engineering geological condition including the topography and geomorphology, the characteristics of rock and soil, the groundwater and the human engineering activities. Affected by landslide, Precipitation, earthquakes and human activities often induce or accelerate the reactivation of the ancient landslide.

The main reason for reactivation of the ancient landslide on the both sides of the river is the vertical erosion of river valley and the river scouring which caused a big steep slope in the overhead of landslide. The precipitous face formed by runoff scouring would led fracture system to progressively develop. The vertical unloading crack will be find at the top, the surface water enters into the slope by unloading cracks, and the rock mass in the lower part of the slope is soaked and softened by groundwater. The rock is softened after water absorption, resulting in the decrease of strength and the formation of a soft layer.

Meanwhile the groundwater level suddenly raised or lowered serious impact the characteristic of rock and soil. The new sliding will show a characteristic of the displacement may occur by slow, secular, differential slippage as well as by sudden rupture. The stress of the slope is adjusted continuously during the slow sliding process, when the water level of the river is stable, the influence of groundwater is no longer strong, the deformation of the new slide body will gradually become slowly. In the process of the reactivation of the ancient landslide there are many features of potential sliding surface, secondary slip happened when the tensile crack link to other potential sliding surface. With the constant change of water line and the river flushing action carried away the fine particle making the front of slope with loose structure and the porosity gradually increase, which caused local collapse and formed a new free surface breaking the original stress balance.

Seismic shake loose effect will be caused by earthquake, the external load on the slope in the balance state is increased, breaking

the original stress balance, stress redistribution produces new structural planes. Under the impact of seismic wave, the landslide revival induced, old landslide deposit become loose and provide a effective channel for groundwater, it accelerate the revival of the ancient landslide under the influence of groundwater.

When the soil structure is loose, the permeability is good and under the continuous heavy rainfall, the soil water content of the slope increases, the slope body weight is increased, and the effective stress of the sliding surface is reduced,

As the result, osmotic pressure increase the sliding force of slope. At the same time, the dynamic water pressure increases the sliding power, the soil of sliding zone is softened by the water, and the shear strength is greatly reduced.

Soft and hard rock with alternative has poor mechanical properties, generally speaking, the surface rock mass is in a strong weathering state. The rock mass is easily softening and break with the influence of rapid downcutting of the river flushing and groundwater

In summary, this paper will take an example of an old-landslide revivification expound the enginnering geological conditions and backgroubd.

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Investigation on the landslides triggered by the 2016 Kumamoto Earthquake, Japan

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Abstract

On 16 April 2016, a Mw 7.0 earthquake occurred in Kumamoto city, Japan. The main shock triggered many fast landslides in Kyushu Region. Among them, two large landslides, namely the Aso Bridge landslide and the Aso Volcanological Laboratory landslide were investigated in this work. Their topographical and geological conditions and motion features were investigated by using an unmanned aerial vehicle (UAV) and portable dynamic cone penetration tests (PPTs).

The Aso Bridge landslide (Fig.1) lies between elevations of 385 m and 725 m, with a total estimated volume of about 1,980,000 m^3. The main body is composed of cohesive soil with lapilli and block. The sliding distance of the this landslide was long, the sliding direction almost unchanged from the scarp to the toe, and the sliding speed was rapid.

The Aso Volcanological Laboratory landslide lies on a slope between 483m to 582 m, and the total volume is about 81,000m3, with an average thickness of 4.5 m. The main body is composed of Kusasenrigahama volcanic pumice tephra beds.

Based on a 3D SPH model, the post-failure behavior of these two landslides were simulated. Their propagations were reproduced and the time histories of the velocity and run-out distance were obtained.

Fig.1 The front view of Aso Bridge landslide

Acknowledgments

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Invited Lecture 5

Drought induced soil desiccation cracking behavior

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Abstract

Better understanding the desiccation cracking behavior of soil is essential in analyzing drought effects on soil hydraulic and mechanical properties through consideration of the atmosphere-ground interaction. In this investigation, initially saturated soil slurry was prepared and subjected to continuous drying in laboratory. The weight of the specimens was recorded at different intervals to calculate the water content and determine the soil water evaporation curve (SWEC, evaporation rate versus water content). The void ratio at different water contents was determined by taking small soil clods for the measurement of volume, and then the soil shrinkage characteristic curve (SSCC, void ratio versus water content) was obtained. During drying, a camera was mounted above soil specimen and the development of surface cracking was monitored. Image processing technique was employed to quantitatively analyze the morphology characteristics of the surface crack patterns, and the soil cracking characteristic curve (SCCC, surface crack ratio versus water content) was determined. The results show that the evaporation, shrinkage and cracking processes of the initially saturated soil can be divided into distinct three stages. The cracking occurs at constant evaporation rate stage where the soil is still fully saturated. The increase of surface crack ratio is accompanied by a decrease of void ratio. The development of cracks tends to stop when the shrinkage limit is reached.

Fig. 1 Desiccation cracking pattern of soil.

Acknowledgments

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Ground motion and its engineering implications in Kathmandu valley during the 2015 Nepal earthquake

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Abstract

On 25 April 2015, a powerful earthquake (M_w7.8) hit central Nepal and heavily affected a large part of mountainous area including the capital city of Kathmandu. It killed nearly 9,000 people and destroyed nearly 800,000 public and private buildings. The Kathmandu valley witnessed heavy damage in hundreds of reinforced concrete buildings particularly in the valley center.

Lack of ground motion sensors in the country has led to only estimated shaking intensity in the affected areas, but six stations in the Kathmandu valley have more or less revealed the nature and intensity of the ground motion. The valley center experienced a long-period shaking while the periphery had short-period shaking. Probably due to the dominant long period shaking in the valley center, most tall buildings (>10 stories) and tall historic structures with low natural frequency sustained heavy damage although variation in sediment type and thickness, structural design, and quality control might have led to different amount of shaking and different damage levels in the tall as well as short buildings. This study particularly focuses on understanding the effect of ground motion on building damage during the 2015 Nepal Earthquake.

The methodology used mainly involves microtremor survey on the valley ground (before the earthquake: Paudyal et al. 2012) and on a total of 44 tall buildings (after the earthquake) and adjacent ground points. Data analysis reveals that not all but most tall buildings in the Kathmandu valley underwent severe shaking during 0.5s to 1.5s dominant period of the ground motion, which seems to have led to heavy damage in infill brick masonry walls of the tall buildings (Fig. 1).

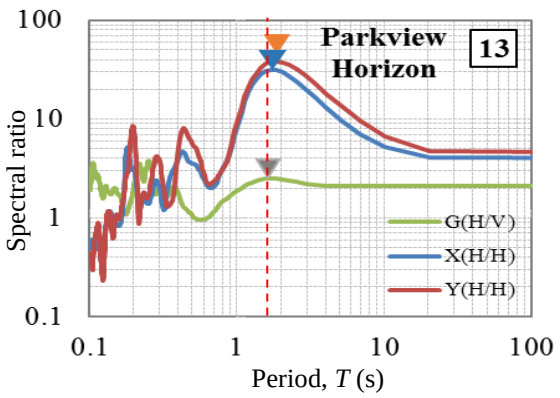

Fig. 1: Typical spectral ratios for a tall building and adjacent ground (G: Ground, X: Building in X-dir., Y: Building in Y-dir.)

Acknowledgments

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Sediment transfer patterns at the Yangjia catchment in Beichuan after the 2008 Wenchuan earthquake

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Abstract

The 2008 Wenchuan earthquake triggered tens of thousands landslides, producing a huge amount of loose material hanging on hillslopes. The loose sediments from the coseismic landslide deposits could be reactivated or even transformed into debris flows during heavy rainfalls. The sediment transfer patterns in mountainous catchments were strongly controlled by debris flows. However, sediment transfer is often difficult to be quantified due to the lack of good quality DEM data as well as the spatio-temporal variation of landslides and debris flows activity.

In this study, we took the Yangjia catchment in Beichuan as an example to quantify the sediment transfer. There were five debris flow events occurred in the catchment, among which the one on 24 Sep, 2008 and on 10 July, 2013 were relative larger. High resolution image and DEM measured by UAV in 2016 were used for the analysis. Based on the available imagery, we created a landslide inventory indicating the changes of the loose deposits on hillslope and in channel in the period of 2008 (after the earthquake), 2010 and 2016. Multi-temporal DEMs of pre-earthquake, 2011 and 2016 were used to compare three cross sections along the channel and to calculate the changing volume of deposits in the channel.

The results show that there are still 70% of coseismic landslide deposits stored on hillslopes, which could be transformed into debris flows by rain storms. The gully channel has been risen by 15 m on average. The annual sediment yield from the Yangjia catchment to the main river (Duba river) over the years from 2008 to 2016 was estimated to be $105\times10^3 m^3/a$, causing the rising of the Duba river for 4-12 m.

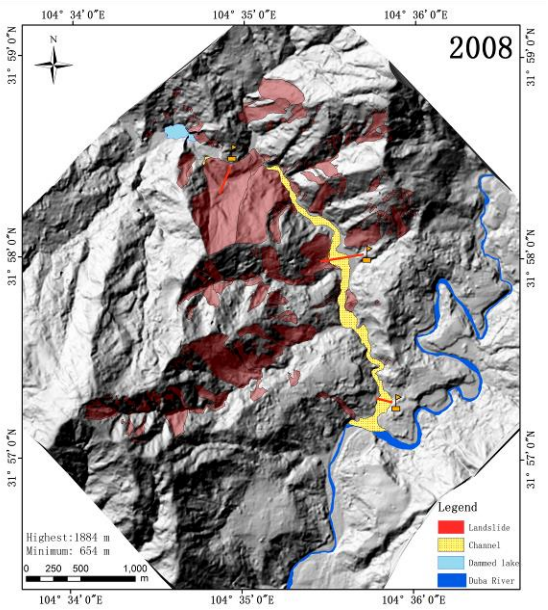

Fig.1 Landslide and channel deposit mapping of the Yangjia catchment with the location of three cross sections (CR1-CR3 from upstream to downstream).

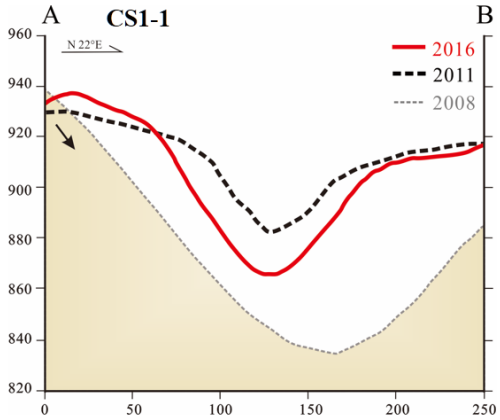

Fig.2 Cross section 1 along the channel

Acknowledgments

This work was supported by the Fund for Resilience to Earthquake-induced landslide risk in China (Grant No.41661134010), Fund for Creative Research Groups of China (Grant No. 41521002), the AXA Research Fund (ARF), the Fund from Land and Resources Department of Sichuan Province (Grant No. KJ-2015-01).

Living on the donuts –sea and coastal hazards in the age of climate change and the anthropocene

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Abstract

Human societies have developed on a donut, a small fringe of land in between the central "donut-hole" of mountainous, steep-slopes areas and the surrounding seas, both these areas are essential to human activity, and the flat coastal plain have historically been favoured interfaces where human have preferentially developed their activities. The sugar-coated energy and resource rich area is however a hazard-prone area, which will be first impacted by climate change and the human-impacts on the environment. The present lecture relies on examples from Christchurch City in New Zealand, Tokyo and the Tohoku area in Japan to investigate the specific challenges that await our societies mosty developed in coastal plains. Along the course this lecture, I will (1) demonstrate that coastal development and its resource rich area is also a risk rich area; (2) before explaning the issues and the worsening of present issues that are awaiting during the course of climate-change induced sea-level rise; (3) and I will terminate this presentation by integrating the anthropogenic specifics that bring another layer of complexity in the environmental hazards, disaster risk and vulnerability realm.