Proceedings of the 16th International Conference on Soil Mechanics and Geotechnical Engineering

doi:10.3233/978-1-61499-656-9-3209

Technical session 4a: Slope stability and landslides

Séances techniques 4a: Stabilité des pentes et glissements de terrain

H. Nakamura - *Tokyo University of Agriculture and Technology, Japan*
K.T. Chau - *The Hong Kong Polytechnic University, Hong Kong*
L. Picarelli - *Second University of Napoli, Italy*
W.A. Lacerda - *Federal Univ. of Rio de Janeiro, Brazil*
D.G. Fredlund - *University of Saskatchewan, Canada*
A. Yashima - *Gifu University, Japan*
K. Tateyama - *Ritsumeikan University, Japan*

Various topics concerning "Slope Stability and Landslides" were discussed in the Technical Sessin 4a. After the Session Chairman, Prof. H. Nakamura (Tokyo University of Agriculture and Technology, Japan), explained the distinguishing characteristics and the management of the session, the General Reporter, Prof. K.T. Chau (The Hong Kong Polytechnic University, Hong Kong), explained the recent trend in this field by examining the papers included in the session, as follows.

1 GENERAL REPORT

There is a total of 35 papers submitted to the session. Table 1 compiles the country distribution of all 35 papers. A total of 20 conutries were represented, including 8 from Japan, 3 from Canada and Italy, 2 from Greece, Norway and Brazil, and 1 from each of the following countries: Algeria, Austria, The Netherlands, Macedonia, Pakistan, USA, Ecuador, Slovenia, Germany, Spain, Russia, Switzerland, Czech Republic and China.

Table 1. Geographical distribution of 35 papers

Country	Paper No.	Country	Paper No.
Algeria	1	Japan	8
Austria	1	Macedonia	1
Brazil	2	Netherlands	1
Canada	3	Norway	2
China	1	Pakistan	1
Czech Rep.	1	Russia	1
Ecuador	1	Slovenia	1
Germany	1	Spain	1
Greece	2	Switzerland	1
Italy	3	USA	1

In 19 out of these 35 papers, some aspects of field studies and geological onees have been included. It means that geological and field studies are constantly of fundamental importance to understand the landslide problems, and that some new methodologies such as electrical resistance tomography devices, GPS satellites or etc. have been employed in the field measurement.

Among 35 papers, 22 of them consists of laboratory studies of some kinds. In addition to the standard element tests such as direct shear box test, ring shear tests, triaxial tests, unconfined compression, torsion hollow cylinder tests, and oedometer tests (compressibility and swelling indices), many experimental studies devoted to more specialized laboratory tests such as model tests were vigorously carried out.

Many papers include the topics on the analytical approach. In general, the numerical analyses can at least be subdivided into the traditional limit analysis for determining the factor of safety, and more versatile numerical simulation method, such as finite element method (FEM) for modeling slope deformation under excitations. Nine out of 35 papers used FEM analysis for either back analysis or simulations, whilst only 2 used limit analysis. It is perhaps true that limit analysis is still widely used daily in engineering practice of slope design, but, clearly, many authors recognized that the traditional limit analysis cannot predict landslide as a function of time and cannot predict the progressive and creeping nature of landslides. Therefore, numerical methods appear to be important in investigating the progressive process of landslides. Among all these analyses, only two papers deal with debris flow. This may due to the fact that debris flow deals with fluid more than solids and, thus, is a highly interdisciplinary topic. However, a lot of disasters are induced due to debris flow all over the world, and thus the research for its prevention is expected to be positively tackled also in the field of Geotechnical Engineering.

Although many of these studies are either directly motivated by rainfall-induced landslide and indirectly related rainfall, the earthquake-induced landslides have been attracted. The shaking table tests to reappear the slope failure due to the earthquake is employed as the effective methodology for understanding the phenomena. There are also some studies focus on landslides induced by human activities, such as coal mining, construction of tunnels, buildings, and highway. Although in mainland China, a lot of landslide problems are related to the construction of dams and hydropower plants, unfortunately there is no representative papers being submitted to this conference.

There are at least 8 papers devote to the problem of creeping movement of slopes. There are some topics concerning the change of suction due to the rain fall and its effect to the stability of the slope. They are expected to play an important role in the prediction of the slope failure.

In the reports, recent disasters due to the slope failure were also reported with some photographs. They included not only a huge scale of landslide in Switzerland but also the submarine landslide induced by Tsunami. He also introduced his recent research on the soil nails as a method for slope remediation.

Photo 1. Model experiments for soil nails in The Hong Kong Polytechnic University

2 SHORT PRESENTATION

After the general report, some topics were addressed by four panelists for presenting some points at issues in discussion to the participants

Prof. L. Picarelli (Second University of Napoli, Italy)

Prof. Picarelli discussed the problem of soil weakening which is responsible for long-term failure of natural slopes in OC clay. He stressed that soil weakening is caused by pre-failure plastic strains that induce changes of soil fabric and structure. It can consist in time-depending decrease of the peak shear strength due to essentially volumetric strains (softening) or in the mobilization of post-peak shear strength due to essentially deviator strains (strain-softening). Typically soil slopes accumulate both volumetric and deviator strains associated with changes of boundary conditions, thus either softening or strain-softening can take place, leading to long-term slope failure. However, several processes of deformation can cause similar effects, governing the mobilised shear strength in landslides. Besides well known mechanisms described in the literature, as swelling induced by cutting or erosion, progressive failure and so on, other processes poorly investigated, as osmotic phenomena caused by infiltration of fresh water in highly plastic clay of marine origin, or rotation of the principal stresses due to plastic adaptation, should be accounted for.

Unfortunately sometimes more than one mechanism can act at the same time in the same slope.

Photo 2. Shallow slides along gentle slopes in saturated clay shale

Prof. W.A. Lacerda (Federal Univ. of Rio de Janeiro, Brazil)

Professor Lacerda introduced the phenomenon in which the saturated, long colluvial deposits move with a low speed and in a long period in Tropical Regions. In Parana State, Brazil, colluvial deposits are piled up along the lower declivities on the residual soil and the base rock mass to form more than 10 colluvial tongues. Thier typical dimensions are 200-450 m of length, 100-150m of width, 8-30 m of mean thickness and 15-17 degree of slpope angle at the bottom of moving colluvialm filling.

They are moving with a low speed and some damages are observed on a neighboring pipeline and roads. He investigated on the detail of the geotechnical profile in the site and collected some Denision samples near the sliding surface. The results of some direct shear tests on undisturbed Denison samples (submerged state) made it clear that the residual friction angle roughly half of the peak friction angle. The relationship between the movement of the colluvium filling and the rainfall is continuously measured in the site.

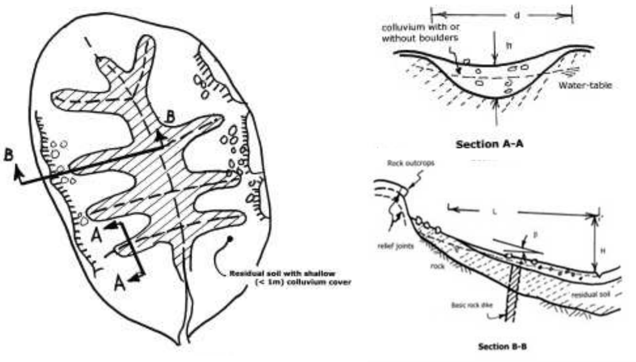

Figure1. Continuous formation of colluvial deposits along the lower declivities

Prof. D.G. Fredlund (University of Saskatchewan , Canada)

Professor Fredlund made a short presentation titled by "Where are we going in terms of the analysis of landslides?". He started his presentation with a brief overview of where we have been and stated the significant changes that are taking place with regard to slope stability analysis.

Limit equilibrium methods have been so widely used as a representative analytical method for landslides. However, there have been some gradual changes in methodology that are emerging with regard to slope stability analyses. Various limit equilibrium methods of slices differ primarily in the manner in which the normal force at the base of the slice is computed and the elements of static equilibrium that are used when solving for the factor of safety. Therefore, more advanced method is requested to be developed by deleting the diversity due to the difference in limit equilibrium methods. He suggested that the advances in the analysis for the factor of safety of a slope can be presented in the form of two "steps". The first "step" involves the use of stress analyses to compute normal stresses at the base of each slice. The computed factors of safety are referred to as the "enhanced limit" method for the calculation of the factor of safety. The second "step" involves the use of optimization theory. The application of optimization theories to the analysis for the stability of a slope essentially removes the assumptions related to the shape of the critical slip surface. In other words, the shape of the critical slip surface becomes a part of the analytical solution through optimization techniques such as Dynamic Programming.

Finally he pointed out that advancements in computer technologies make the emerging changes for slope stability analysis attractive from the standpoint of engineering practice.

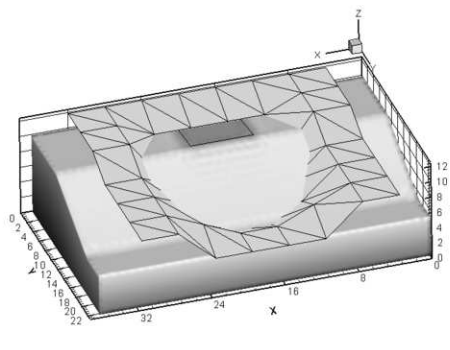

Figure 2. 3-Dimensional dynamic programming analysis

Prof. A. Yashima (Gifu University, Japan)

Professor Yashima suggested the new method for simulating the large deformation (flow) due to slope failure with the fluid dynamic (CIP)-based numerical method. Although FEM is effective method for predicting the trigger of slope failure, it can not simulate a large deformation (flow) due to slope failure. Therefore he applied the fluid dynamics (CIP)-based numerical method for slope failure. In the simulation, he used the Bingham model includes shear strength of soil as a constitutive model. Performance of the proposed numerical method was discussed based on the comparison between numerical results and experimental results through a model experiment for granular flow, and the validity of the numerical result has been confirmed. He also introduced an user-friendly input-output-system for CIP-based numerical method.

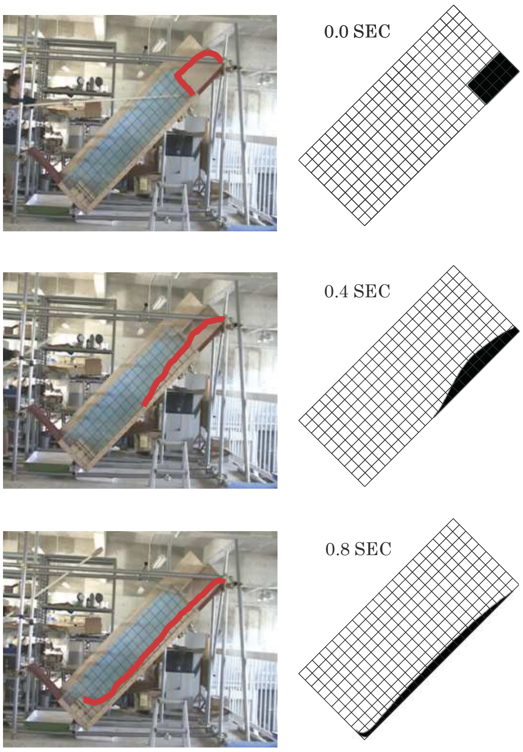

Figure 4. Experiment and simulation for granular flow

After the short presentation by four panelists, technical discussion was held with the participants in the floor. Although some questions were asked to the panelists from the floor on their presentation, the time for presentation by panelists had been extended for their substantial content and thus enough time for fruitful discussion can not be secured.