

An application of the diffusion and advection equations for the evolution of a gravel slope An application of the diffusion and advection equations for the evolution of a gravel slope

Zheng-yi Feng^{1*}, Yen-min Liu¹
FENG, Zheng-yi^{1*}, Yen-min Liu¹

¹Department of Soil and Water Conservation, National Chung-Hsing University, Taichung, Taiwan

¹Department of Soil and Water Conservation, National Chung-Hsing University, Taichung, Taiwan

The diffusion and advection equations were manually coupled to model the evolution of a gravel slope in Da-keng, Taichung, Taiwan. The two equations were discretized using finite difference method and coded in Matlab environment. Field topographical surveys of the gravel slope and previous digital terrain data were used for calibrating the diffusion and advection coefficients used in the equations. We show that the evolution of slope decline and parallel retreat can be well described the gravel slope evolution in Da-keng. A non-homogeneous slope was simulated by varying the corresponding diffusion and advection coefficients for the non-homogeneous slope.

キーワード: Slope evolution, diffusion model, advection model

Keywords: Slope evolution, diffusion model, advection model

伏野地すべり地における地震時の間隙水圧変動について Fluctuation in excess pore water pressures triggered by earthquakes at the Busuno land-slide

大沢 光^{1*}, 岡本 隆², 松浦 純生³, 阿部 和時⁴

OSAWA, Hikaru^{1*}, OKAMOTO, Takashi², MATSUURA, Sumio³, Kazutoki Abe⁴

¹ 日本大学大学院生物資源生産科学専攻, ² 森林総合研究所, ³ 京都大学防災研究所, ⁴ 日本大学生物資源科学部

¹Graduate School of Bioresource Sciences, Nihon University, ²Forestry and Forest Products Research Institute (FFPRI), ³Disaster Prevention Research Institute (DPRI), Kyoto University, ⁴Bioresource Sciences, Nihon University

はじめに

近年新潟県中越地震や岩手宮城内陸地震などの M6 以上の大規模地震が多数発生し、それらにより多くの地すべり災害を引き起こし、死者をだした。地震動を起因とする地すべり地の間隙水圧変動を観測した例は少なく、未だ不明な点が多くあり、メカニズムの解明が必要である。その為、本論では地すべり地において観測した 5 つの地震による強震動および間隙水圧変動を用いて、地震時における間隙水圧変動特性について考察した。

解析に用いる地震動と間隙水圧計の情報

我々は新潟県の伏野地すべり地にて、地震動と間隙水圧の観測を行っており、当地区において地震時に間隙水圧の変動がみられた為その結果を示す。

本研究では以下の 5 つの地震動、2004 年新潟県中越地震 M6.8(EQ1) およびその最大余震 M6.5(EQ1')、2007 年新潟県中越沖地震 M6.8(EQ2)、2011 年長野県北部地震 M6.6(EQ3) およびその最大余震 M5.8(EQ3') を用いて解析を行なう。2010 年より地震計を伏野地すべりへ設置した為、それ以前 (EQ1-EQ2) の強震データは防災科学研究所 K-net 安塚 (NIG 024) のデータを利用した。また、伏野の最大加速度および最大速度を推定するため、司・翠川 (1999) の断層最短距離を用いた距離減衰式によって求めた。

間隙水圧計の位置は地すべり移動土塊内において移動量の大きい中部ブロックに設置しており、観測は 10 分間隔で行なっている。EQ1-EQ2 間では 5 基の観測値を用い、その後積雪による計器の圧壊の為 2 基を新設し、EQ3,3' では 2 基の観測値を用いた。

結果と考察

5 つの地震動発生時に全ての間隙水圧計で変化が生じた。EQ1-2 では地震発生後に静水圧を超え、スパイク状の上昇及び減少を示している間隙水圧の観測値が得られた。これらの水圧変動は透水性の低い地盤内部で地震による急速な弾性圧縮を受けたことにより、土粒子間の空隙が体積変化して一時的な間隙水圧変動を示していることが考えられる。本稿では、地震によってスパイク状の上昇・減少を示す過剰間隙水圧について、静水圧を 0 としてそこから増減分を絶対値で表したものを過剰間隙水圧の絶対値とする。

解析結果から、最大加速度が大きくなるに連れ水圧変動も大きくなる傾向が見られた。5 つの地震動の中で最も高い最大加速度は EQ3 時の東西 236Gal、南北 382Gal、上下 108Gal であった。また、EQ3 における周波数特性では、3Hz 付近に卓越周波数帯が存在していることが分かった。その時の過剰間隙水圧変動は過去の例の中で最も高い 15kPa であった。また EQ3 以外の地震動による過剰間隙水圧変動は大きくて 1kPa 程度であることから、EQ3 時の水圧変動が極端に大きいことがわかる。その要因として EQ3,3' 発生時には地すべり土塊上に 3m の積雪があり、積雪層によるすべり層の圧密、および積雪層の長期載荷によるすべり層の圧密という要因が重なり大きな水圧変動が起こった可能性が考えられる。また、岡本ら (2006) は本対象地において EQ1, EQ2 では地震前よりも水圧の高い状態が 8-24 時間継続し、それは地震時の地盤の弾性圧縮変形 (スパイク状の上昇) と塑性的な圧縮変形 (高間隙水圧の残留) の両成分で構成されたためと報告している。EQ3,3' では同様の事例が見られ、地震以前の静水圧よりも高い状態が 1-3 日間継続した。

文献

司宏俊・翠川三郎 (1999):断層タイプ及び地盤条件を考慮した最大加速度・最大速度の距離減衰式, 日本建築学会構造理論文集, No.523, pp.63-70.

岡本隆・松浦純生・浅野志穂・竹内美次 (2006):活動中の地すべり地における中越地震発生時の移動および間隙水圧変動特性, 日本地すべり学会誌, Vol.43, No.1, pp.20-26.

キーワード: 地すべり, 地震, 過剰間隙水圧, 最大加速度

Keywords: landslide, earthquake, excess pore water pressure, peak ground acceleration

小型水槽実験装置を用いた水流に関連した自然電位変動に関する研究 The sandbox experiments to understand Self-Potential changes associated with water flow

大坪 大^{1*}, 矢部 修平¹, 服部 克巳¹, Adrin Tohari², Khori Sugianti²
OTSUBO, Hiroshi^{1*}, YABE, Shuhei¹, HATTORI, Katsumi¹, Adrin Tohari², Khori Sugianti²

¹ 千葉大学大学院理学研究科, ² インドネシア科学院

¹Graduate School of Science, Chiba University, ²LIPI, Indonesia

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

In this study, the sandbox experiment has been conducted to understand the relation between water flow and self potential using a network of electrodes set in the tank. For the sandbox system, it is possible to control the water table and easily to drain water from the tank and infiltrate water into the tank. Controlling water flow in the tank, we conducted repeatedly experiments. In consequence, we could get the relation between the magnitude of water flow and self potential. The details will be given in our presentation.

アナログモデル実験による断層崖斜面の形状と崩壊パターンの検討 Geometry and pattern of slope failures at a fault scarp in analogue models

中桐 寛仁^{1*}, 宮川 歩夢², 山田 泰広¹

NAKAGIRI, Hiroto^{1*}, MIYAKAWA, Ayumu², YAMADA, Yasuhiro¹

¹ 京都大学大学院工学研究科都市社会工学専攻, ²JAMSTEC: 独立行政法人海洋研究開発機構

¹Department of Urban Management, Graduate School of Engineering, Kyoto University, ²JAMSTEC: Japan Agency for Marine-Earth Science and Technology

斜面崩壊現象は、地質的・地形的な要因により不安定化した斜面が、豪雨や地震動などを引き金に崩壊する自然現象で、我々の生活に大きな被害を与える。そのため、将来の集中豪雨や地震に備えて、斜面不安定化に寄与する各種要因を分析し、崩壊危険性を評価しておくことは大変重要である。本研究では、斜面崩壊の地質的・地形的要因である逆断層活動に注目し、断層活動に伴う斜面の形状や発達、崩壊について、アナログモデル実験を用いた検討を行った。実験では豪雨の再現は行わず、また静的な条件で実験を行うことで地震動等の影響を無視できるようにした。これにより、斜面の発達および崩壊に関する逆断層活動のみの影響を考慮できるように工夫した。

本実験では、逆断層変位する基盤岩上に堆積する堆積層に発達する斜面を模擬した。30度の角度で切断した木製ブロックを基盤岩に見立て実験装置内に配し、その上に堆積層として乾燥砂を堆積させた。そして、木製ブロックに非常にゆっくりと逆断層変位を与え、乾燥砂に斜面を発生させた。実験中の斜面の発達と崩壊の様子を、デジタルカメラを用いて、上方および側方から一定時間間隔で撮影した。得られた画像をデジタル画像相関法 (Digital image correlation : DIC) により解析することで、モデルの変形過程を時系列で取得し、堆積層表面の斜面の3次元形状およびその崩壊パターン、断面の断層活動などについて、互いの関連性について検討した。

斜面の3次元形状を観察すると、斜面長に関わらず、斜面下端に一定幅の急傾斜部が見られた。一方、モデル側方の画像から可視化される断層は、地表付近では、常に斜面下端でほぼ一定の幅で活動していた。両者は大変整合的であった。このことは、斜面傾斜分布中の急傾斜部の存在から、斜面下に存在する断層の位置や幅を推定可能であることを示唆している。

斜面は、堆積層表面に直線状に発生するのではなく、ある程度の曲率を持って発生した。上盤側へ凸な位置では、上盤上昇量が大きく、多く崩壊面積の大きく斜面上部から崩壊する「大規模斜面崩壊」が多く発生した。一方、下盤側へ凸な位置では、上盤上昇量が小さく、大規模斜面崩壊は少なかった。また、上盤上昇量が増大し斜面が発達するにつれて、斜面下端は徐々に直線的になり、斜面上端は斜面発生初期の曲率が増幅された形状へと変化した。このように、観察された現象には、斜面発生初期の曲率に依存する傾向が見られた。このことから、表面における斜面の曲率より、大規模斜面崩壊の危険性を定量化できる可能性が示唆される。

キーワード: アナログモデル実験, 逆断層, 斜面崩壊, デジタル画像相関法, 3次元表面形状

Keywords: analogue modeling, reverse fault, slope failure, DIC, 3D topography

3D remote-sensing study of the spatial distribution of landslides in SE Weihe Basin, central China

3D remote-sensing study of the spatial distribution of landslides in SE Weihe Basin, central China

Gang Rao^{1*}, Aiming Lin¹, Bing Yan¹

RAO, Gang^{1*}, LIN, Aiming¹, YAN, Bing¹

¹Graduate School of Science and Technology, Shizuoka University

¹Graduate School of Science and Technology, Shizuoka University

Many factors may be responsible for the occurrence of landslides, such as moderate to large magnitude earthquakes, typhoons as well as human activity. The landslides triggered by the earthquake are mostly concentrated in and around the epicentral area of large earthquakes over a distance of tens of kilometers, as well their distribution is strongly affected by the seismic faulting (e.g. Ren and Lin, 2010). To learn the distribution of landslides and its controlling factors is vital to make the risk assessments of landslide hazard, especially within the seismic active region.

Remote-sensing techniques have been applied to learn the spatial distribution of co-seismic landslides, based on cross-check of the reflection features of images acquired before and after the earthquake. Meanwhile, Digital Elevation Model (DEM) data with world-wide coverage (e.g. 90-m SRTM data) were also used to learn the topographic features of locations where landslides occurred (e.g. Ren and Lin, 2010). However, most of by previous studies are limited to analyze in map-view. Here we present a case study of the distribution of landslides and its relation to the active normal faults in SE Weihe Basin, central China, by using the 3D remote-sensing techniques which has been previously applied to detect the locations of seismic faults associated with moderate to large magnitude earthquakes.

In this study, higher resolution remote-sensing images (1-m IKONOS and 0.5-m WorldView data) were processed and analyzed in 3D perspective views by draping them on the 30-m ASTER Global Digital Elevation Model (ASTER GDEM) data. High-resolution Google Earth images if available were also used to cross-check the spatial distribution of landslides. Based on the results of our analysis, we then conducted the fieldwork to validate the interpretations of the remote-sensing images.

The results of our analysis indicate that the landslides are mostly distribution in the regions between the Weinan and Huayin city, which was inferred as the epicentral area of 1556 M8.5 Huaxian earthquake. Meanwhile, the landslides (including the largest Lianhuashi and Zhangling landslides) are generally developed upon the steep slopes (30°-65°) within a narrow zone with width of ~8-11 km and ~3 km along the Huashan Piedmont Fault and Northern Margin Fault of the Weinan Loess Tableland, respectively. The distribution of landslides was affected by the active faults and slope morphology in study area. The devastating 1556 M8.5 Huaxian earthquake caused widespread damages in the densely-populated region around the Xi'an city, an old capital of China, resulting in more than 830,000 deaths (largest total ever claimed), including the people killed by the giant landslides (e.g. Zhangling landslide). 3D remote-sensing techniques show their advantages to precisely constrain the spatial distribution of landslides and thus make the risk assessment of landslide hazard in the seismically active regions, such as the SE Weihe Basin.

References cited:

Ren, Z. & Lin, A. 2010. Co-seismic landslides induced by the 2008 Wenchuan magnitude 8.0 Earthquake, as revealed by ALOS PRISM and AVNIR2 imagery data. *Intern'l J. Remote Sensing* **31**, 3479-3493.

キーワード: landslides, active normal faults, 3D remote-sensing, SE Weihe Basin, central China

Keywords: landslides, active normal faults, 3D remote-sensing, SE Weihe Basin, central China

カルデラ湖, 屈斜路湖の湖底に潜む災害イベント地形 Topographies of hazardous events on the bottom of Caldera Lake Kussharo, Hokkaido, Japan

山崎 新太郎^{1*}, 原口 強²

YAMASAKI, Shintaro^{1*}, HARAGUCHI, Tsuyoshi²

¹ 北見工業大学, ² 大阪市立大学

¹Kitami Institute of Technology, ²Osaka City University

There are a lot of large caldera lakes in volcanic arcs such as Japan. Caldera lakes and their surroundings have good sceneries and hot springs; a lot of resorts located in their lakesides. However, the existence of abundant water in high elevation may provide the risk of the residences around the caldera lakes. The reasons are as follows: volcanic activities exist on the bottom of caldera lakes in many cases, and the inside of caldera rim is steep slope with large difference in elevation, their rims consist of lava and pyroclast which is preferred geology for catastrophic landslides. Volcanic activities and catastrophic landslides may cause overflow of lake water or tsunami. Their risk should be analyzed.

We are trying that analysis for Lake Kussharo in Hokkaido. Lake Kussharo is located in Kussharo Caldera which is the largest caldera in Japan. The lake has 79.3 km² in areas. The elevation of water surface is 121 m a. s. l. Only one river, Kushiro River flows from the lake to the downstream to Kushiro city. The resort area, Kawayu hot spring resort town is developed along lakeside. Volcanic activities are still active in this area. Mt. Atosanupuri erupted during the last few thousand years. The caldera rim has steep slopes and the highest part is 1000 m a. s. l. There are a lot of topographies of huge landslide masses and huge horseshoe shaped cliffs on the slope of rim. The terraces of old lake bottom lie on the wide area from the lakeside to the level of 150 m a. s. l. In addition, we found old terraces at the level of ca. 105-110 m a. s. l. and 95-90 m a. s. l. by our sonic survey. These terraces suggest that the level of water surface has repeatedly fluctuated.

We surveyed topography and geology of the ground surface and the bottom of lake using the sonic survey. In this presentation, we will mention about characteristic topographies related to past hazardous events. In particular, we found the mound-like hills in two areas. One area is ca 1 km in width from north to south and ca 1.5 km in length from east to west. This area has many small mounds, and their maximum size is ca 400 m in width and 20 m in height. Another area is ca 1.2km in width from north to south and ca 0.7 km in length from east to west. This area has also many small mounds, and their maximum size is ca 50 m in width and 20 m in height. These two areas are close to Nakajima Island which is the central cone of caldera. So, we deduce that both mound-like hills were flowed from Nakajima Is. by huge collapses. Also we found other topographies related to past hazardous events: landslide debris extended ca 2.5 km in width and ca 0.5 km in length near lakeside; a landslide involving bedded sediment; small eruptions with lava having width of ca 100 m; and topographies of depression associated with volcanic activities.

There are a lot of landslide masses and horseshoe shaped cliffs on the slope of rim. However, we could not find remains on their feet. Thus, most of their topographies on the rim do not concern recent hazardous events. The topographies we found are clear, so they probably formed after the formation of lake. Hazardous events formed their topographies could cause flood or tsunami, and then further events may occur around caldera lakes. Their risks should be considered for disaster prevention.

Keywords: Caldera lake, Landslide, Natural hazard, Lake Kussharo, Sonic survey