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NATURAL RESOURCES ENGINEERING AND DISASTER MITIGATION FOR INFRASTRUCTURE DEVELOPMENT

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Multi-way landslide and debris flow warning for resilience and sustainable community

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ABSTRACT: Two approaches for landslide and debris flow prediction is presented. The first model based on the detail geotechnical analysis is precise but consume computing time. This approach is suitable for the landslide forecasting by the cetre of command. The second model is based on the statistical approach, it's rather simple, tae less time but less accurate as well. This model is simple and suitable to be used together with the local landslide warning system. Both systems are now in used in Thailand and proofed to be helpful in landslide warning.

Keywords: Landslide, debris flow, geotechnical

1. INTRODUCTION

Landslide is the natural disaster that affected the society in many ways. Landslide research unit, Geotechnical Engineering Research and Development Center (GERD), Kasetsart University has developed landslide and debris flow database of Thailand which contains of almost 40 years of information on landslide events starting from 1970 (Soralump, 2010). Most of the landslides were caused by the slope cutting for road, housing and the use of soil for construction material etc. These landslides were triggered by rainfall and in many cases not a heavy rainfall. On the other hand, debris flows were caused by excessive or extreme rainfall in which the rainfall intensity is very high for several days. In these cases, the debris flow could be occurred regardless of geologic type or land cover type. It can be noticed obviously that the landslides were occurred scattering in the hilly area on the northern and southern part of Thailand. However, debris flows just concentrated only in some area where the north-eastern wind confront with south western wind and create the monsoon trough pass through that area.

Soralump (2007 and 2010) found that the frequency of the landslide event in Thailand increases sharply during the last decade starting from 1996. There might be several assumptions for this but it may be contributed to the rapidly increasing in economics of Thailand before the Asian financial crisis in 1997. Generally, landslide in Thailand happens every year while the large debris flow often occurs every 3-5 years. The average causalities are about 14 lives per year.

2. LANDSLIDE ROCK GROUPS

It is very important to understand the mechanics behavior of residual soil or weathered rock in order to model the landslide behaviour properly. Therefore, the classification of rock group that specifically related to landslide is needed in order to study the residual soil of each rock group in detail. Similar type of rocks, based on their formation, age and statistical record of landslide events, have been grouped together by Soralump et al. (2010) (show as the background map in fig. 1) resulting in 10 rock groups which are: Group 1: Carboniferous-Permian granite has area of 0.74% Group 2: Jurassic-Cretaceous granite has area of 1.84% Group 3: Jurassic granite has area of 4.55% Group 4: Volcanic rock and other intrusive rock such as basalt, andesine, diorite etc. It has area of 3.04% Group 5: Sedimentary rock mainly sandstone, it has area of 17.55% Group 6 Sedimentary rock mainly shale and mudstone (18.79%) Group 7 Sedimentary rock, combination and interbeded or intercalated (7.17%) Group 8: Metamorphic rock has area of 6.3% Group 9: Quaternary sediment has area of 32.89% Group 10: Carbonate rock mainly limestone has area of 7.13%.

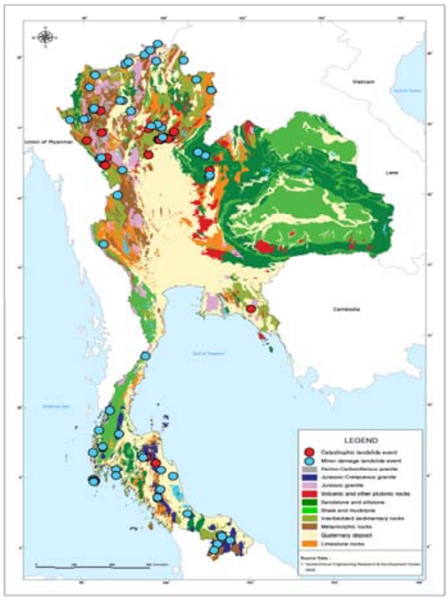

Fig.1: Landslide events from 1970-2006, plotted over the landslide rock group of Thailand (Soralump, 2010)

Quaternary sediment and carbonate rocks are considered has low chance of landslide. The granitic rocks, even though small in area but found to be the highest rate of landslide and debris flow per unit area. Furthermore, this kind of rock contains a powerful force of destroy since its debris flow consists mostly of large rocks and boulders.

3. LANDSLIDE FORECASTING- GEOTECHNICAL MODEL

Geotechnical model including infiltration and stability model were used for predicting the rainfall-triggered landslide. The model is programmed into GIS application in order to make the tool for analyzing the near real time landslide susceptible area. The key information that required for the analysis is:

1. The model of changing in shear strength of soil in unsaturated zone due to the changing in soil moisture content (or metric suction), this characteristics of soil can be determined directly in laboratory by performing the direct shear test to the residual soil samples in various degree of saturation. Mairaing et al. (2005) and Soralump and Torwiwat (2009) has proposed and developed this testing technique called KU-MDS shear test. Based on landslide rock group as described in last section, undisturbed samples of residual soil located in each rock group all over the country have been collected. The total number of over 514 soil samples has been tested for their engineering properties. 307 undisturbed soil samples have been specially tested their shear strength reduction behaviour by KU-MDS shear test.

2. The infiltration model of unsteady and unsaturated flow was modeled using the modified Green and Ampt model. The permeability of residual soil in unsaturated condition (K-Function) and also the rough information of underlain base rock permittivity were determined and estimated. The verification was done by comparing with the field data from the tensiometers and moisture probes in the specific area.

3. The rainfall data, which are the rainfall intensity and its pattern, was determined and used as an input parameter. Direct measurement from automatic rain gauge, radar and metrological model were used. With the later model, the hourly precipitation can be forecast for 72 hours. With that, the early warning can be issued. This is very helpful to save lives.

30x30 m mesh is used in GIS modelling. Each grid cell contain of assumed 6 m thick soil layer with follow the infiltration rules explained above.

Infinite slope analysis is performed every time step of input precipitation in order to obtain the factor of safety of slope at any time. The system is capable in calculating the total of nearly 400 million grid cells. The 6 hours computation time is required for the 72 hours forecasting. The example of the result is shown in fig 2.

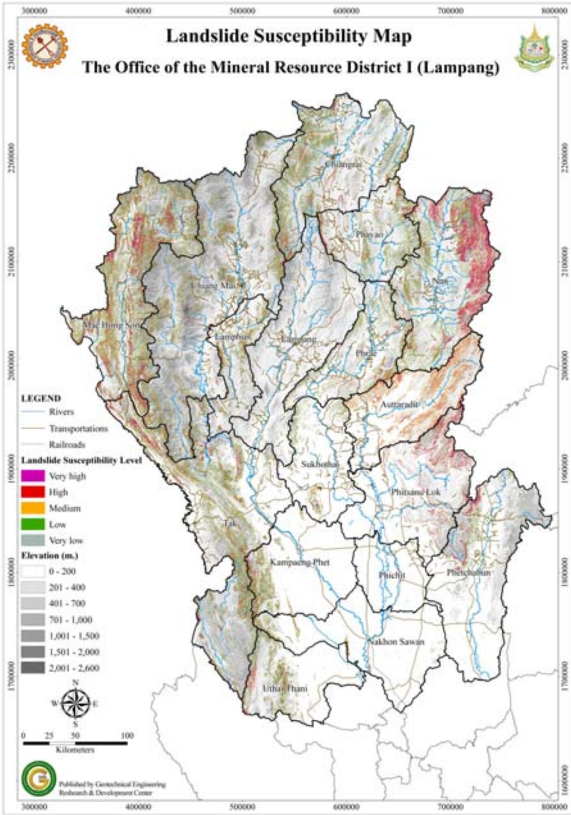

Fig.2: Landslide forecasting system result

4. LANDSLIDE/DEBRIS FLOW- STATISTICAL MODEL

The real time monitoring of landslide and debris flow can be done by using the concept proposed by Okada et al. (1992). The daily rainfall is plotted with the 3 days accumulated preceding rainfall. The critical boundary line can be obtained by keeping track of landslide events and comparing with the precipitation data. The example is shown in Fig 3.

The failure criteria is then programmed into GIS system in order to keep track of landslide or debris flow potential based on the precipitation data. The example of the result is shown in Fig 4.

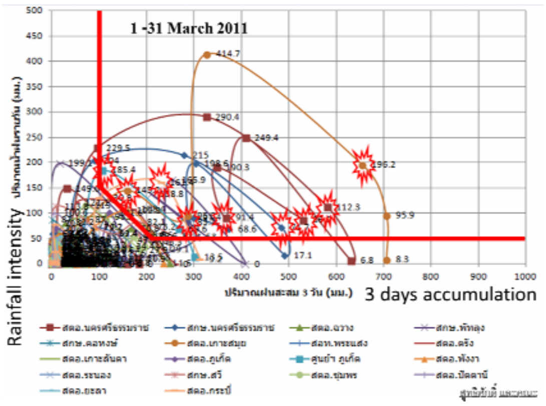

Fig.3: Landslide and debris flow warning curve based on statistical data.

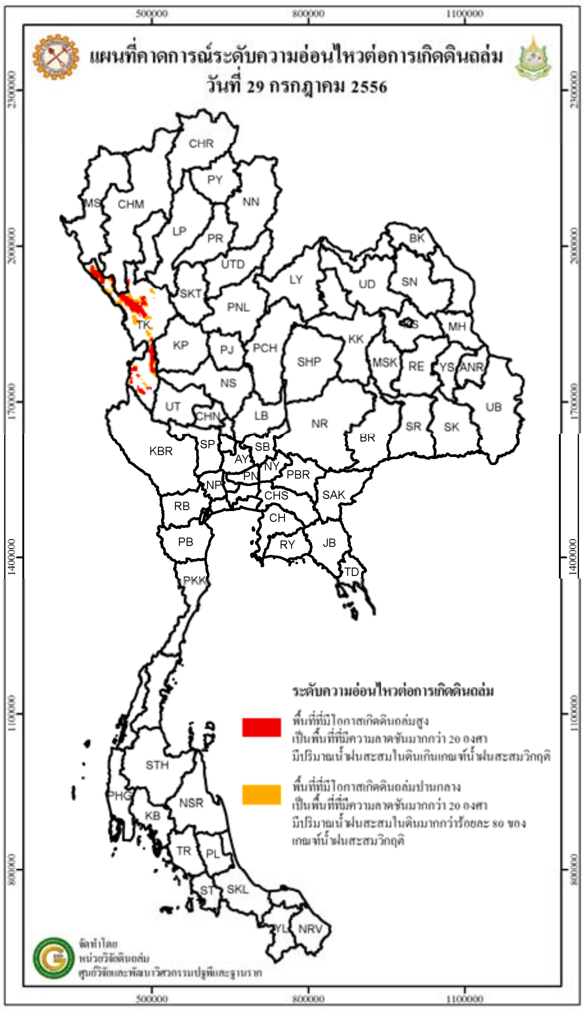

Fig.4: The landslide prediction model based on statistical data.

5. MULTI-WAY LANDSLIDE AND DEBRIS FLOW WARNING SYSTEM

The geotechnical approach for landslide prediction model is suitable for the landslide prediction in specific area. The result is precise but takes time. The later, statistical approach is on the other hand, fast analysis but lower precision. However, it is necessary to use both model as multi-way landslide and debris flow warning system. The detail analysis required the high performance computation tool, therefore it need to be perform at the centre of command. The later model is simple calculation; therefore it can be used for roughly prediction the landslide and debris flow event in the remote area. Fig 5 shows the concept of this system.

Fig.5: Multi-way landslide and debris flow prediction and warning concept.

6. CONCLUSIONS

The multi-way landslide and debris flow warning system was developed by the author and is now using as a warning system in Thailand. The system has flexibility in performing either detail or rough prediction of landslide.

REFERENCES

Mairaing, W., Nongluck & Kulsuwan, B. (2005). Landslide study in Pecthchaboon and Chantaburi.

Okada, K. et al. (1992). Statistical estimating method of railway embankment damage due to rainfall. *In proceeding of JSCE*, No.448/III-19.

Soralump, S. (2010). Rainfall-Triggered Landslide: from research to mitigation practice in Thailand. *Geotechnical Engineering Journal of the SEAGS &AGSSEA*, Vol 41 No.1 March 2010 ISSN 0046-5828.

Soralump, S. & Torwiwat, W. (2009). Shear strength behavior of residual soil in Thailand subjected by changing in moisture content for supporting the landslide warning measure. 14th Civil Engineering Conference, Suranari.

Soralump, S. (2007). Corporation of Geotechnical Engineering data for landslide hazard map in Thailand. *EIT-JSCE Joint seminar on Rock Engineering*, Bangkok, Thailand.