WORKSHOP ON LANDSLIDE AND KARST SUSCEPTIBILITY ASSESSMENT
Pulse Grande Hotel, Putrajaya
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1.0   INTRODUCTION

The workshop on Landslide and Karst Susceptibility Assessment was held on 1st March 2018 at Pulse Grande Hotel, Putrajaya. A total of 67 participants comprised of technical and academic representatives were involved throughout the workshop to share knowledge and discuss current issues on the landslide and karstic hazard in Malaysia. The participants included representatives from the Department of Mineral and Geoscience (JMG), Kuala Lumpur City Hall (DBKL), Universiti Kebangsaan Malaysia (UKM), Universiti Malaya (UM), Universiti Tenaga Nasional (UNITEN), Universiti Sains Malaysia (USM), Public Works Department (JKR), Kumpulan IKRAM Sdn. Bhd. (IKRAM), Gamuda Berhad and others.

This one-day workshop consisted of two main sessions; landslide hazards and karstic hazards, led by NUOF project members from British Geological Survey (BGS) with the aim to inform and explore the processes that cause landslide and karstic hazards in Kuala Lumpur as well as utilizing experiences and methodologies applied in other countries such as the United Kingdom. The workshop was concluded with a constructive final discussion to enhance understanding of the processes and susceptibility assessment methods for the landslide and karstic hazards in Kuala Lumpur as well as to suggest ways to improve the capacity of the geoscience profession in order to create a more robust private sector of geologists who are active in using their skills effectively to help society to be more secure and safer in the future.

2.0   OPENING SESSION

The Workshop commenced with welcoming remarks by **Professor Dr. Joy Pereira, NUOF Malaysian Project Leader.** She expressed her gratitude by taking a great pleasure acknowledging the presence of Mr. Ahmad Fairuz Mohd Yusuf, who is the Head of the Selangor State Disaster Management Unit and YBhg. Dato' Yunus Abdul Razak, Chair of the Board of Geologists Malaysia. She begin her speech with a brief introduction on the NUOF Project which focuses on addressing climatic extremes physical hazards such as flash floods, sinkholes, urban heat, strong winds, landslides, air pollution and conducting a local-level forecasting to improve the predictability of extreme weather events in Kuala Lumpur.In lined with this initiative, the Geological Society of Malaysia and Institute of Geologists Malaysia came up with a flagship to address the risk of hazards in 2015 jointly collaborated by SEADPRI-UKM and University of Malaya. The effort was undertaken to enhance the participation of private sector geologists for disaster risk reduction (DRR) where the three prospective products are DRR showcase platform for private sector companies, DRR solutions platform to present good geological practices and skills, and lastly the DRR expert platform where a list of participating geologist

working in this area is shown. The speaker representing all NUOF project members mentioned that they are glad to offer support on programs on capacity building and professional development of geologist in Malaysia and South East Asia. Ultimately, it is their aim to create a robust sector of geologists while producing a safer society in terms of improving the DRR methods within our region.

This session was followed by a presentation from **Dr. Christian Arnhardt of BGS** on The Language of Susceptibility, Hazard & Risk whom elaborates on those three terms and had a discussion to analyse the different opinions among the participants.The presentation highlighted different susceptibility and hazard assessment methods which are dependent on the scale of study, availability of data and the data quality. The meaning of landslide is explained briefly as a movement of a mass of rock, earth or debris down a slope and the types of landslide is described, such as fall, topple, slide, flow and spread that are differenced based on materials and process. The natural and man-made slope was delivered about the meaning and the differences. Natural slope is a slope formed by natural geological process, whereas the man-made slope is alteration of a natural slope by civil engineers by cutting to make steeper slope and embankments to accommodate infrastructure. He remarked that man-made slope failure is the main issues and will be discussed later on.

The next part is the susceptibility. The meaning of the susceptibility is the potential for an area to be subjected to the hazard. Susceptibility is based on examining the causative factors for the hazard and determining whether these causative factors could be present at the locations and does not include an indication of probability or magnitude. So, he remarked that susceptibility is the likelihood that landslides will occur in an area, where and no information on when landslides are expected. Several meanings of susceptibility from difference sources are briefly explained. He also stated that it is important to see the landslide happened in the past for the assumption for the future. If the future landslides will be caused by the same reasons that have caused landslides in the past, we could use the information and can assume whether the area is prone to landslide. Susceptibility may also include a description of the velocity and intensity of the existing or potential landsliding. Thus, he commented that it is important to require data for susceptibility. For susceptibility, we cannot say where something happened as we need information about the landslide initiation data, for instance landslide type and relative spatial and temporal probability.

Another important point is the scale. The scale used is also essential for the objectives that need to be achieved. The example of the scale is national, regional, medium, large and site investigation scale. Each scale has its own objectives and has its own possibilities for data collection. The availability of data greatly determines the possibility of using particular susceptibility methods, so he stated it was needed to know what types of data that we have in order to choose the suitable methods and techniques. Then, he also remarked about the validation. The data also need to do the validation that mainly based on historical data. A susceptibility map is useless unless it is validated the spatial and temporal validation. There are no standards, guidelines or recommended practices for validation/evaluation of susceptibility models.

The susceptibility map is to show the potential area suspected to landslide. He commented that the main issue is that if the susceptibility map is still valid. The data that had been using if anything change as asusceptibility map is valid until any of the (intrinsic or triggering) factors changes. He commented about susceptibility that if the available data, data quality and objectives should determine which

method is used. There were many papers dealing with the comparison of methods for susceptibility assessment. Susceptibility research is quite often more 'model driven' rather than data driven and more process driven. So, he commented that we need to think about the data that will be using rather than methodology and knowledge from the experts that know the area. More integration of geological / structural geological information in analysis and validate is essential so that the data is can tells us about the assessment.

He then proceeded with hazard as a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption or environmental damage. He also stated the natural hazard that occur is by natural process that may cause loss of life and damage within a given area and in a given period of time. He also commented about the human interference on natural slope. Human intervention can increase the frequency and severity of natural hazards or may also cause natural hazards where none existed before also reduces the mitigating effect of natural ecosystems. Hazards assessment is the process of estimating for defined areas the probabilities of the occurrence of potentially-damaging phenomenon of given magnitude within a specific time period. So, he stated that hazard need data like landslide initiation and landslide runoff data, such as the type, volume and speed of landslide, and spatial and temporal probability.

He also highlighted hazard assessment approaches that can be used, depend on the data that we had. The example of approaches is qualitative, quantitative, deterministic and probabilistic approach. Qualitative approach is when mathematical functions are used to denote relationships between variables considered to quantify the hazard. Qualitative approach is the usage of a ranking such as high, moderate and low to assess a hazard event. Qualitative approach is the usage of a ranking such as high, moderate and low to assess a hazard event. Probabilistic approach is when after identifying the hazard that affect the planning area and assessment of the impacts from those hazards, a probability analysis is undertaken. Probabilistic landslide hazard assessment helps to determine spatial, temporal and size probability of landslides.

Risk is the combination of event with negative consequence. A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend. Lastly, he asked the participants to list down what the definition that we used and if we used have the same understanding to BGS for susceptibility, hazard and risk at the board and will be discussed later on.

Dr. Frederick F. Tating, Department of Mineral and Geoscience Malaysia gave a remarkable presentation on "Landslide Susceptibility Assessment – A Malaysian Approach" which exhibits the method adopted by JMG in managing a landslide event and the assessment involved. Dr. Frederick presented his study on landslide occurred in Sabah where he applied the combination of heuristic method (knowledge driven) and statistical method (data driven) whereby the need of expert decisions are required for the former, supported by statistical analysis. The speaker explained exhaustively on the work flow of the approach from preparation of landslide inventory map, mapping and analysis, landslide susceptibility assessment from inventory form, producing landslide causal factor maps, conducting bivariate statistical analysis and finally transferring the information and displaying in

ArcGIS, ArcView or ILWIS software. Some of the sources required to form the landslide database includes aerial photo, satellite imagery, LiDAR results, field data proforma and previous reports. In the end, it is relatively important to do a weight determination by overlaying landslide density map with causal factor map and doing a ground check on field to interpret the factors involved. He suggested that the reliability of map is depended upon various factors such as the scale of analysis, the completeness of the landslide inventory map, selection of parameter maps for the analysis and the analysis methods. The landslide susceptibility is calculated by combining the landslide weight and knowledge driven weight, while the validation of landslide map is done by using statistical method based on success rate curve

3.0   LANDSLIDE HAZARD

The session starts with a presentation by **Dr. Helen Reeves, BGS** that covers landslide event inventories, discussion about Malaysian Landslide Event Inventories, BGS GeoSure Methodology for Landslide Hazard Susceptibility and it ended with a Q&A session on assessments before lunch break. Landslides are becoming more prevalent these days with the changing climate, rapid development, uncontrolled deforestation and the natural state of the slope itself thus it is crucial to map the landslide susceptibility to predict the hazard and reduce the risk posed to the nearby community. Therefore it is important of understanding the landslide types and the respective triggers such as precipitation and environmental condition. Dr. Helen showed BGS's National Landslide Database and the Great Britain National Landslide inventory which was developed in Microsoft Access and Oracle database with a complete set of attributes. The application of BGS Landslide inventory is myriad where it is used as information and communication source with the government, local municipality, transport & infrastructure owners, university researchers, commercial companies and members of the public. Rapid statistics are provided for a range of stakeholders which facilitates in the decision making process and it is effectively used to underpin various nationally important projects. Landslide hazard and risk were also discussed in this session where she mentioned that the word 'prediction' should be avoided in this case as it have a certain degree of meaning. The speaker suggested to adopt an approach where a more dynamic model is used instead of a static model where landslide event information (date/time/type/magnitude/frequency) are all being considered. She pointed out that geologists must engage with other departments such as the Meteorological Department Malaysia to improve local forecasting and enhance predictability of hazard and risk.

In the subsequent part, Dr. Helen moderated a discussion with the participants to look on the similarities and differences related to landslide in both regions. The question that was raised was; does rainfall induce landslides, and most of the participants agreed to that to some extent. Mr. Jeyapalan from DBKL stated that landslide is part of the natural cycle and humans could not completely mitigate the hazard but considerable effort must be taken for mitigation works to reduce the hazard. The local authority must be responsible and handle the issues more seriously as it involves with the safety of the community. Dr. Helen informed that the noticeable difference are vegetation and climatic role which controls the type of landslide. Dr. Askury pointed out that tropical weathering profile is significantly different from the UK whereas the soil weathering condition appears to be similar to the glaciated profile in UK that will lead to similar problems. Dr. Azlan raised an issue on data transfer from infrastructure to be supplied to the BGS landslide inventory, how responsive they will be in providing the reliable data and methods to enforce them to provide data. Moreover, Dr. Helen

suggested that geologists must be tactful and share their existing knowledge on the issue to influence the developers. In return, BGS will share data to them and offer advice where necessary especially when it involves the financial aspects of their business and their reputation. Dr. Param informed that there's a significant difference in the soil composition in Peninsular Malaysia and Sabah which form different weathering material due to variety in mineral composition. The monmorillonite clay is ubiquitous in Sabah's soil quickly expands and holds more volume of water which create cracks to the surface whereas the kaolinitic material found in Peninsular Malaysia soil is able to absorb less water reducing the conduction of water out of the slope and creating an overflow as silt occupies the drainage. Besides that, Dato' Zakaria proposed to use geological terrain mapping and correlate with geological susceptibility maps as we have yet to integrate into planning. Programs on landslide mapping must be conducted nationally to investigate the cause and improve the current project-based mapping on certain areas. A comment made by Mr. Fairuz from Smart Selangor showed that hilly terrain is of high demand, regarded as an exclusive property which give revenues to the local authorities. Thus, it is necessary for them to be informed on the condition of the hill slope area and have a complete inventory that maps high risk area to conduct a development with proper slope mitigation work. Another enquiry that was posed was the probability of small scale triggering event to escalate to a disaster in the future, and the need to better understand the symptoms of slope failure with the help of experts. Lastly, Mr Zuhal proposed that geologists must progress towards process driven analysis as long as the triggering factors, soil condition, density and rheology are determined.

The final part of this session was a discussion on BGS GeoSure Methodology for Landslide Hazard Susceptibility that utilizes geomorphological mapping, statistical modelling and heuristic susceptibility analysis based on geology, slope angle and discontinuities. This method produced national susceptibility hazard maps backed by a national landslide database of more than 17,300 entries where modified DTM combined with geological factors from statistical and heuristic analysis and ranked as A- E (low- high). The ranking scheme enables to prioritise area while highlighting potential for rotational and translational failures. Quantitative analysis is conducted by bivariate statistical analysis focused on regional or detailed assessments with support of a certainty factor model. The landslide susceptibility index is a frequency ratio approach based on observed relationships between landslides. In conclusion, BGS has implemented an effective approach built on heuristics techniques which are considered more valid for this terrain. The speaker talked on landslide domains in Great Britain which separates into similar landslide process thus one can analyse the susceptibility on a more regionally specific basis and highlights six landslides. The domain is used to determine potential impacts of landslides from Forestry Commission land and to assess the impact of landslides to Network Rail. She mentioned that landslide impact is highly variable, not always related to size and it is important to determine the risk beforehand by calculating the product of hazard, vulnerability and exposure.

4.0 KARSTIC HAZARD

The final session was conducted by **Dr. Vanessa Banks, BGS** whom shared her perspective on karstic hazard she encountered and studied in the UK. This session centred on karst terminology, processes, karst event inventories and methodologies for karstic hazard assessment and susceptibility. Karst terminologies, processes and relationships were described and a case study of Peak District was presented to show ground conditions of surface and subsurface karst and hazard assessment of the area. The limestone are weathered due to periods of exposure with evidence of volcanic activities seen by the volcanic dust appearance which then resulted karstic clay formation. The material was subjected to mineralisation and altered to dolomite, where stylolites were formed and mineralisation related to paleokarst occurred. Meanwhile, caves are formed due to the effect of sea level fluctuations, forming incision and terraces (knick points) with apparent dolines, sinkholes and limestone pavement (clints and grykes features). Hazard assessment and zonation looks at the susceptibility of reef limestone in proximity to allogenic recharge and also susceptibility of dolomitised limestone on southern part of the platform.

The speaker then elaborated on BGS approach on karst hazard susceptibility assessments on five types of karstic rocks which are salt karst, gypsum karst, chalk karst and limestone karst. Each presents a different type and severity of karstic geohazard which are related to the rock solubility and geological setting. The BGS GeoSure methodology is GIS based and contains copious dataset with records of hazard events integrated with digital map data in order to examine the likelihood of subsidence due to karst collapse. The discussion among participants produced an assumption that Malaysia's karst is classified as extreme and complex stage depending on locations. Dr. Ros from UM stated her study found out that the lineaments detected from aerial photograph showed the dolines in Ipoh are aligned with major trench and these features will dissolve vertically as major conduits. Dr. Vanessa raised an issue of paleo-river systems in Klang Valley where certain places have very deep trough in Simpang formation and these systems are important for the study of karst today. Mr. Devandran from Gamuda shared his experience in dealing with karstic bedrock through acoustic borehole televiewer which are fixed in boreholes to detect limestone cavities and structural discontinuities underground.

5.0 FINAL DISCUSSION

To conclude the one-day workshop, a final discussion was done to gather knowledge, issues as well as recommendations to move towards the production of reliable landslide and karstic hazards susceptibility maps. The discussion was conducted between the participants led by the geophysical hazard thematic leader, Dr. Ng and Dr. Helen. The objectives of the discussion is to gain insight and feedback on the ongoing NUOF project where the project seeks for helpful suggestion on how to improve the methodology.

The discussion highlighted the need for experts to put more focus on paleo-landslides as it often occur at bigger scales. The challenges faced in terms of karstic hazards include oversimplification and inclination of site investigation (SI) information to follow the engineering terms instead of geological terms. The importance of having current data as opposed to just previous data was emphasized as the results will be more reliable. Another highlighted issue would be the challenge of doing the inventory as the karst cavities in KL are hard to gauge due to their complexity and embedded nature. The

usefulness of the karst susceptibility map was also discussed and the requirement of boreholes data in Malaysia to be submitted in digital format was suggested to be made a rule or mandate in the contract. The participants also have a notion that the MRT project is a good opportunity for geologists to understand the Kenny Hill Formation and KL Limestone better. The need to redefine the purpose of project for doing karst susceptibility mapping was also suggested to convince the authority and community.

Dato' Zakaria suggested that the team get involved with the MRT project by obtaining data from them either by logging cores, site investigation reports and organizing a site visit while tunnel excavation is being done. Another issue that was raised is the challenges in doing a landslide inventory. The enquiry was answered by Mr Nizam where he proposed to do a proper delineation between two formations and to identify an effective methodology to get the first approach of susceptibility map. The reliability and authenticity of borehole data is of utmost important where information on karst cavities can be identified although there might be a variety within different boreholes. Researchers must not rely on existing data and extrapolate for the areas that are lack of data instead deepholes must be done to get own controlling data. Mr. Jeyapalan mentioned the team must take advantage of recent rock data obtained from MRT Project, KLCC, MRCB-KL Sentral and Mid Valley's development as deep core loggings carried out are valuable for the research. A representative from Gamuda enquired on how the susceptibility maps can be utilized by the project developers while Dato' Zakaria mentioned the need to redefine the purpose of project for doing karst susceptibility mapping to convince the authority and community. Dr. Ng mentioned that the team will do a site visit to determine the contact between Kenny Hill and Kuala Lumpur Limestone while checking the weathering profile for a more concrete evidence. The submission of SI reports in AGS digital format from developers to JMG would be a requirement through this project. Prof. Joy stated an issue of the jurisdiction of DBKL has on sharing data with private consultants and federal agency while Mr. Jeyapalan commented that DBKL only receives data which were approved by the architects firm and suggested that a proper system of collection must be implemented by JMG and coordinated with DBKL.

In a nut shell, the participants were content with the outcomes of the workshop and have generated new collaboration and expanded their networking. The organizers were thankful for the beneficial input from all participants as well as the fruitful sharing from BGS and are looking forward to coordinate the next task. Generally, the objectives of this workshop has been fulfilled, and we have managed to build capacity among project members, share challenges and suggestions to improve the geohazard susceptibility assessment. The event had instilled awareness and developed good understanding of the processes that cause the geophysical events for management work of potential hazards associated with landslide/ slope instability.