Lowland Technology International 2020; 22 (1): 035- 039
International Association of Lowland Technology (IALT): ISSN 1344-9656
Special Issue on: Engineering Geology and Geotechniques for Developing Countries

Research Paper

Slope Failure Due to Effect of Damrey Typhoon in Penang Island

F. Ahmad [1], A.S. Yahaya [2], M. Azmi [3] and N. Mustaza [4]

ARTICLE INFORMATION

Article history:

Received: 20 January, 2020
Received in revised form: 22 April, 2020
Accepted: 30 April, 2020
Publish on : 06 June, 2020

Keywords:

Slope failure
Soil resistivity
Landslide
Erosion
Soil Nailing

ABSTRACT

The monsoon season in month of November till December in 2017 has left Penang Island in devastated conditions where, hill slope landslide, erosion and flood took place around Penang. This was a monsoon season, however these occurrences were not normal and Penang has accounted many slope failure, building construction collapse and flash floods. A series of failure occurred at the surrounding slope at USM has occurred over the past 10 years and therefore remedial work were carry out to improve the slope on site. During the seasonal rainfalls, the slope was heavily eroded and all the trees and grouted slope which was in placed before, fail to sustain from the water movement. Then a series of Soil Resistivity test on site was then explored to foresee the major problems and to counter the stability. By doing this investigation, the purpose is to understand, analyse and rectify the situation of slope failure. From this study, we have conducted the soil mapping of the ground to further understand the soil condition so that all the counter measures can be done effectively. The rectified was done as an emergency condition and was prepared immediately; therefore, soil nailing and grouting method were proposed along with different counter measure to stabilized the slope. From the study it shows that after rectification and placing the right infrastructure to the slope, the system in place are now stabilized and able to cater heavy downpour after completion.

1. Introduction

In Malaysia, hilly area in Penang Island can be considered as a potential for development because of the attractive setting they provide. However, hill area development is often open to risks in constructions, people and environment. Examples of environmental risk at hill areas are erosion, sliding and fall of slope which creates many issues and problems. Slope failure is one of the common natural disaster that have been occurred of the common natural disasters that have been occurred after event of rainfall and stormy weather. From the experience, slope failure, landslide, flooding and soil erosion has been an example which can cause injury to person, danger to life, environment and economy (Ahmad et al., 2013; Ali et al., 2011; Yahaya et al., 2013; Khan and Lateh, 2011), especially in Penang area.

[1] Professor, School of Civil Engineering, Universiti Sains Malaysia, Engineering Campus, 14300 N. Tebal, Penang, MALAYSIA, cefahmad@usm.my
[2] Professor, School of Civil Engineering, Universiti Sains Malaysia, Engineering Campus, 14300 N. Tebal, Penang, MALAYSIA, ceshukri@usm.my
[3] Senior Lecturer, School of Civil Engineering, Universiti Sains Malaysia, Engineering Campus, 14300 N. Tebal, Penang, MALAYSIA
[4] Senior Lecturer, School of Physics, Universiti Sains Malaysia, 11800, Penang, MALAYSIA
Note: Discussion on this paper is open until December 2020

Hilly area experience incidence result of landslide threat caused by slope instability, especially the intensity of rainfall in Malaysia is very high and hence, the slope is easily exposed to erosion and landslide. It is also a triggering factor for other country where this phenomenon is the main concern where rainfall events occurred (De Vita et al, 1998; Iverson, 2000; Larazzi et al., 2011; Larazzi and Picaretta, 2018).

Climatic change and heavy rainfall over the past years has caused the above mentioned problem in Penang. The effected site caused by Typhoon Damrey from 1st to 4th of November 2017 has a number of locations in Penang which has shown slope failure, erosion and flooding. It was deeply empathises with the suffering that many Penangites and Kedahans have had to endure over the unprecedented flash flood and landslide mishaps that happened over the weekend of 4-5 November 2017 as shown in **Fig.1,** the infographic on flood victims by Bernama News, 2017. These incidences have also caused Universiti Sains Malaysia (USM) to deal with the landslides near the student residential in the campus.

2. Background

The locations of the site are shown in **Fig. 2**, where the failure has started in earlier years, however it was spread to the new places depending on the influences caused the slope erosion triggered by rainfall. The rainfall recorded over a 24-hour period from from 1st till 4th Nov 2017 was 315 mm, which was 40 mm more than on September 2015.

Fig. 3 shows the failure that has occurred just after the stormy weather in November 2017. The picture shows the severity of the area which create streams of water flowing from the hill top and caused failure within the ground of USM. The overflow of water has created tress falling, transporting soil, debris and blocking sump drain at the top and bottom of the hill.

Fig. 1. Infographic On Flood Effected Vicitms (Bernama News, 2017).

Due to the failures, further investigation and assessment was done to consider the best solution for corrective measure which required fast action for effective and safe for the community of USM hostel and public that use the amenities. This study was done under the USM healthy campus program for the sustainability for tomorrow since 2003 (Ahmad et al., 2013).

3. Ground Investigation

A 2D resistivity tests were carried out to further investigate the ground conditions of the area to support in designing for ground stabilization. The survey was carried out with 2.5 m minimum electrode spacing using Wenner Schlumberger. The data collected were processed using RES2DINV software. The 2D were mapped as shown (L1) and Pole Dipole array (L2-L5) was second applied as shown in **Fig. 4**, the location of each line.

4. Analysis

The profiles (L1-L5) trends S-N direction to a length of 100 m (**Fig. 5**). The inversion displays the ranges by resistivity values from 5 Ohm.m to 1000 Ohm.m indicating the overburden material which consist of saturated zone (1-100 Ohm.m) and alluvium (silt, clay and sand) with resistivity values of 100-800 Ohm.m up to a depth of 15 m. The intermediate second layer exhibits resistivity values that ranges from 1000-2000 Ohm.m represents the weathered granitic rock. The high resistivity zone with range of > 5000 Ohm.m at depth of > 15 m indicates granitic rock.

From the result obtained, the weak zone is relatively thick with an estimated thickness of 15 m with low resistivity value (1-100 Ohm.m) and alluvium (100-800 Ohm.m).

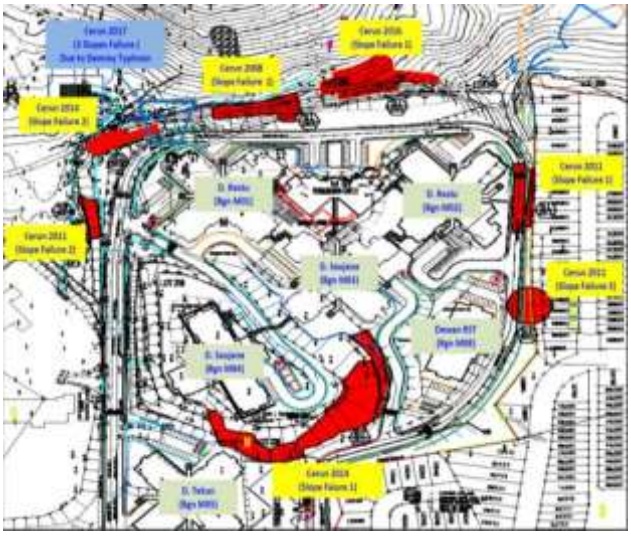

Fig.2. Location of the slope failure at USM Hostel

F. Ahmad et al. / Lowland Technology International 2020; 22 (1): 035- 039
Special Issue on: Engineering Geology and Geotechniques for Developing Countries

Fig. 3. A Slope failure adjacent to USM Hostels.

Fig. 4. 2D Resistivity line across the USM Slope.

The shallow fractured/ weathered granite with resistivity values of 1000-2000 Ohm.m therefore is considered unstable. There were boulders located at a distance of 75 m of L1, 25 m and 80 m of L2, 85 m of L3 and 60 m of L5 covered by top soil. Therefore, it shows that how the ground can be vulnerable if the water seeps through the soil and weathered rock.

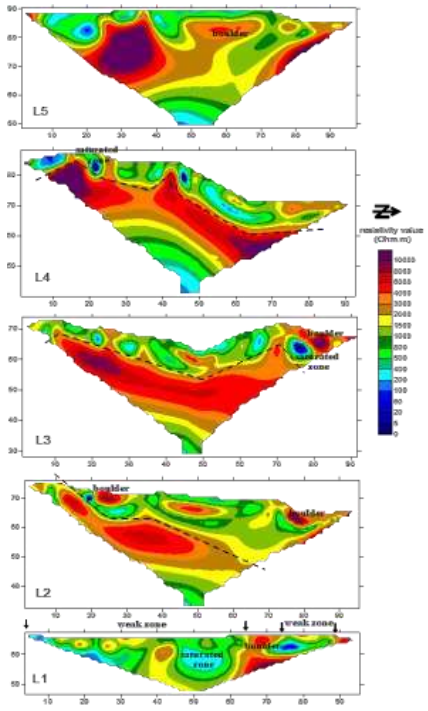

Fig. 5. 2D Resistivity survey mapping.

Legend

Fig. 6. Plan of slope stabilization of as buit plan

5. Conclusions

After all the observations and study carried out at site, a necessary step was considered, which is to rectify the slope failure as indicated in **Fig. 6**. The steps taken were:

i. All exposed slope failures were covered with plastic sheets to make sure no direct water from the rainfall shall further erode the slope,
ii. All trees on the slope were cut off.
iii. Clearing all large and loose debris on the slope to avoid further rolled over the slope.
iv. All drains and sump were cleared from blockages to avoid self-creating streams and transporting loose and weathered material to other locations.

Then rectifications of the slope were stabilized by using soil nailing and grouting to the slope with proper construction in accordance to specifications as shown in **Fig. 5**. The monitoring using inclinometer and piezometers installed shows that the slope is in stable state after completion for more than 6 months. This proceed many materials into the compacted one. The main study can be used to proceed further based on the regulation change in each single day.

Acknowledgements

Special thanks to Development office of USM, USM RUI Grant (PAWAM/8014094) and the School of Civil Engineering and School of Physics team and Terokajaya that has conducted the construction and assisting USM for remediation process.

References

Ahmad, F., Yahaya A.S., Osman, M.A., Wong, P.L. and Ahmad, B.I, 2013. Development of WILMS: Well Inform Landslide Monitoring System for USM Healthy Campus, Landslide Science anPractice - **2**: Early Warning, Instrumentation and Monitoring, Springer, ISBN 978-3-642-31444-5: 549-557.

Ali, M.M, Ahmad, F., Yahaya, A.S. and Farooqi, M.A., 2011. Characterization and hazard study of two areas of Penang Island, Malaysia, Human and Ecological Risk Assessment, **17** (4): 915-922.

Bernama News, 2017. The Flood on 4th Nov 2017: Penang, Perak and Kedah, posted 5th Nov 2017.

De Vita, P. and Reichenbachwith, P. contributions by Bathurst, J.C., Borga, M., Crozier, G.M., Glade, T., Guzzetti F., Hansenz, A. and Wasowsk, J.,1998. Rainfall-triggered landslides: A reference list, Environmental Geology, August 1998, Springer-Verlag, **35** (2–3): 219-233.

Iverson, R.M., 2000. Landslide triggering by rain infiltration. Water Resources Research, **36** (7): 1897-1910.

Jamalludin, D., Ahmad, F. And Roslan Z.A., 2014. Characteristics of soil taken from slope failures in sedimentary and granitic residual soils. International Journal of Civil & Environmental Engineering, IJCEE-IJENS, **14** (6): 31-37.

Khan, Y.A. and Lateh, H., 2011. Failure mechanism of a shallow landslide at Tun-Sardon Road Cut Section of Penang Island, Malaysia, Geotechnical and Geological Engineering, **29**: 1063-1072.

Lazzari, M., Piccarreta, M. and Capolongo, D. 2011. Landslide triggering and local rainfall thresholds in Bradanic Foredeep, Basilicata region (southern Italy). Landslide Science and Practice. Volume 2. Early warning, instrumentation and modeling. In Proceedings of the Second World Landslide Forum, Rome, Italy, 3-9 October 2011; **2**: 671-678, ISBN 9783642314445.

Lazzari, M. and Piccarreta, M., 2018. landslide disasters triggered by extreme rainfall events: The case of Montescaglioso (Basilicata, Southern Italy) Geoscience 2018, **8**, 377: 1-17.

Muravyev, Ya.D., 2005. A gas emission in a cirque – the possible cause of the Kolka Glacier slide by a disaster scenario. Materialy glatsiologicheskikh issledovaniy, **98**: 44-55.

Nosenko, G.A., Rototaeva, O.V., Nikitin, S.A., 2017. Specific changes of the Kolka Glacier (the North Caucasus) from 2002 to 2016. Led i Sneg. Ice and, Snow. 2017. **57** (4): 468-482. doi:10.15356/2076- 6734-2017-4-468-482 (In Russian)

Ondrášik, R. and Rybář, J., 1991. Dynamic Engineering Geology (Dynamická inžinierska geológia – in Slovak), SPN, Bratislava.

Shakya K. 2017. More than two years of Earthquake in Nepal, 2015: Challenges in Crisis Management, Organized by Chungbuk National University, 410 Seongbong-ro, Heungduk-ku, Cheongju, Chungbuk, December 15-17, 2017, Korea: 361-763.

Yahaya, A.S., Ahmad F., Mohtar, Z.A. and Suri, S., 2017. Rainfall erosivity variability for Penang Island. Geotechnical Engineering Journal of the SAEGS & AGSSEA, **48** (1): 1132-1136.