Landslide Risk Prioritization of Tsunami Affected Area in Thailand

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Abstract: 220 locations of previous and existing landslides were prioritized in order to indicate the landslide hazard zone. Weighting factor method is used to determine consequence and likelihood score. A pair of those scores were plotted in F-N chart in order to indicate the landslide locations that fall into risky zone. The soil samples from the risky zone were then collected and performed strength reduction index (SRI) test and found that granitic soil can reduce its strength when saturate up to 40% reduction.

Key Words: Landslide, Risk, Tsunami

1. Introduction

The incident on 26 December 2004 draws public attention on earthquake hazard in Thailand. However, landslide hazard is the natural hazard that happens almost every year and causes economics and life losses. In order to manage the land properly after tsunami incident, landslide hazard zoning needed to be done. Department of Mineral Resources in corporation with Geotechnical Engineering Research and Development Center (GERD), Kasetsart University is responsible for the project of developing landslide hazard map in 6 provinces affected by Tsunami. One of the important analyses that needed to be made is prioritization the previous and existing landslide hazard areas. The study was done in 6 provinces including Ranong, Phang-nga, Krabi, Phuket, Trang, and Satun (Fig. 1). 220 locations of previous and existing landslide area were investigated in order to collect the data for various analyses including the risk prioritization of these areas.

2. Risk cost comparison

As stated above, even though tsunami caused great loss of life and economics damages, however its likelihood of occurrence is far lower than landslide hazard. Department of Disaster Prevention and Mitigation (2006) has reported the casualties in Thailand for 2004 Tsunami event to be 5395 of death and missing person and 30,483,232,557 Baht of economics loss. However, Risk Management Solution (RMS, 2006) reported the return period of 2004 Indian Ocean Tsunami is considered to be greater than 500 year. Therefore, annual risk cost for that tsunami event would be equal to 60 Million Baht per year. On the other hand, in August 2006 large landslide has happened in Autaradit province in the northern part of Thailand. That event caused 83 lives and 308 Million Baht (Department of Mineral Resources, 2006) and its return period is considered to be about 5 years. Annual risk cost is then about 60 Million Baht which is the same as 2004 Tsunami event. The estimated annual risk cost for those events shows that landslide hazard is a serious threat to people and economics.

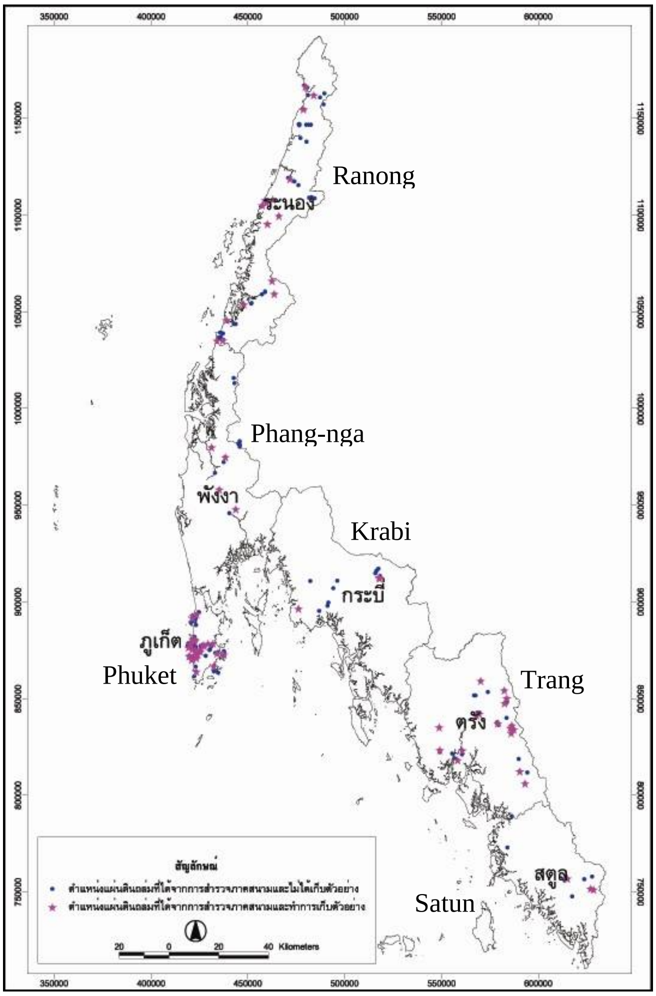


Figure 1. Study area

3. Factors considered

Since landslide is a serious threat, landslide risk analysis need to be performed in order to develop landslide zoning. Areas of 6 provinces were selected. As indicated before, the 220 locations of previous and existing landslide were investigated. In order to perform landslide risk prioritization, the following factors are considered as consequence factors:

1. Loss of life
2. Economics loss
3. Size of landslide

The following factors are considered as factors that related to landslide likelihood:

1. Past event
2. Geography
3. Geology

The first two factors are factors that related to consequences. Later three factors are related to likelihood of landslide occurrence. Those factors are the major factors considered in the analysis. Each major factor contains related minor factors. Therefore, the required data collected from 220 locations are as follow:

1. Loss of life
    a. Number of villages down slope
2. Economics loss
    a. Number of residential buildings
    b. Government official buildings and transportation routes
    c. Hotels and tourist attractions
3. Size of landslide

Landslide likelihood factors:

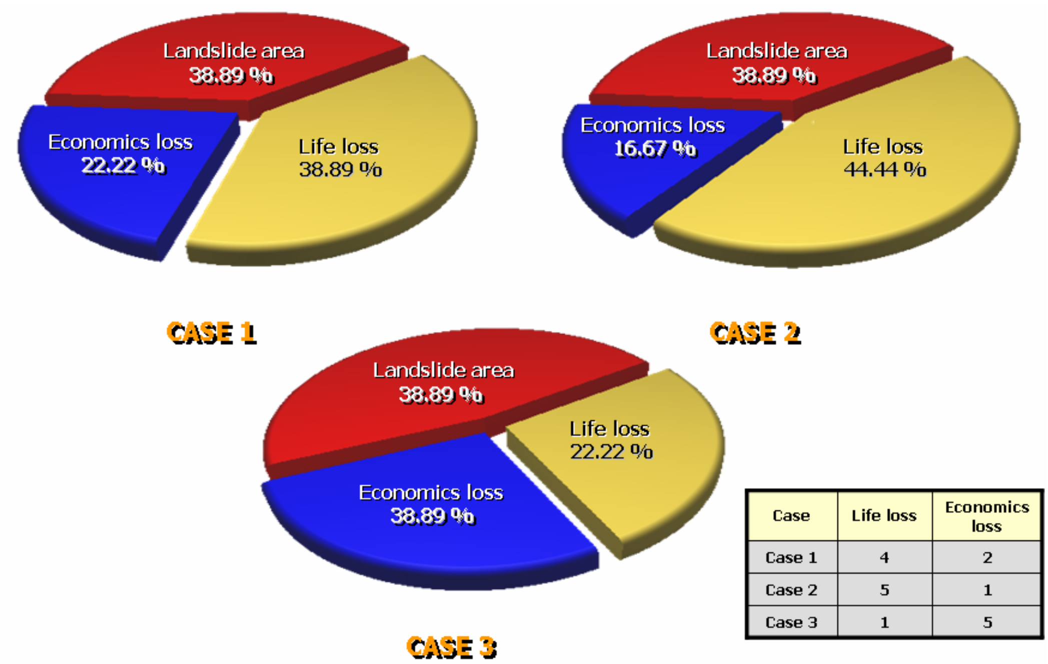
1. Past event
    a. Number of past event
    b. Type of landslide (natural or man made)
2. Geography
    c. Slope angle
    d. Distance from landslide to nearest village
    e. Watershed area
3. Geology
    f. Rock type
    g. Clay mineral content
    h. Joint and fracture content
    i. Presence of fault
    j. Degree of weathering

4. Landslide Risk prioritization by weighting factor method and F-N chart method

Weighting factor method (Pungsuwan, 2006) was used to calculate consequence and likelihood score in order to rank the landslide hazard area by F-N chart (Christian, 2004). The analysis was done by assigning the weight to the major and minor factors by expert opinion using scoring matrix technique. The matrix works by comparing the important of a pairs of factor and gives score from 1 to 5 which range from the most important to the least important. The consequence factors were weighted through the matrix as shown in Table 1 and the result of three cases (difference score rating assigned to economics and life loss factor) is shown in Fig 2. The weighting procedure was done for likelihood factors as well and the result is shown in Fig 3. Fig. 4 summarized the weight assigned to both consequences and likelihood factors.

Table 1. Weighting process for consequence factors

Major factor		1 Economics loss	2 Life loss	3 Landslide area	Point of Summary	Prioritization Point (%)
1	Life loss	-	4	3	7	38.89
2	Economics loss	2	-	2	4	22.22
3	Landslide area	3	4	-	7	38.89



Case	Life loss	Economics loss
Case 1	4	2
Case 2	5	1
Case 3	1	5

Figure 2 Weight of consequence factors of various conditions

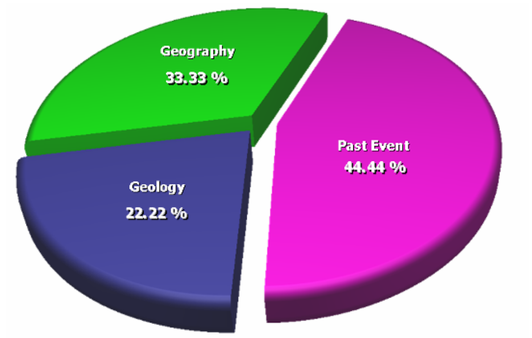


Figure 3 Weight of likelihood factors

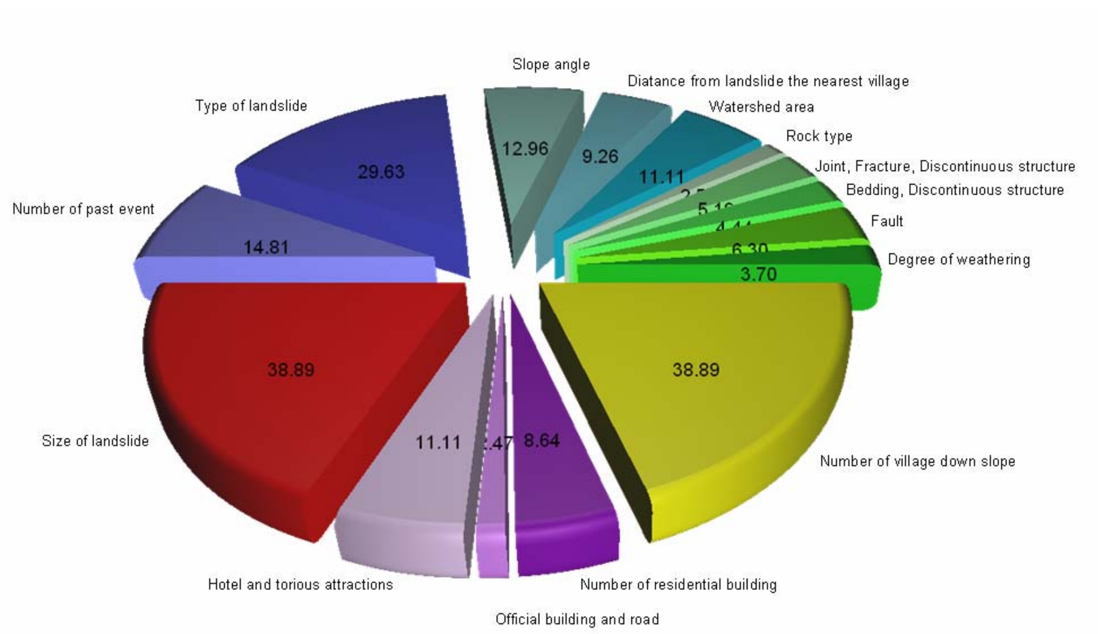


Figure 4 Summarize of likelihood weight and consequence weight factors

5. Scoring

Fig. 5 shows how scoring was done. The scores were assigned to various conditions of minor factors in both consequences and likelihood factors. Data from field investigation were used to explain the range of conditions of each minor factor. The example of score level is shown in Fig 6.

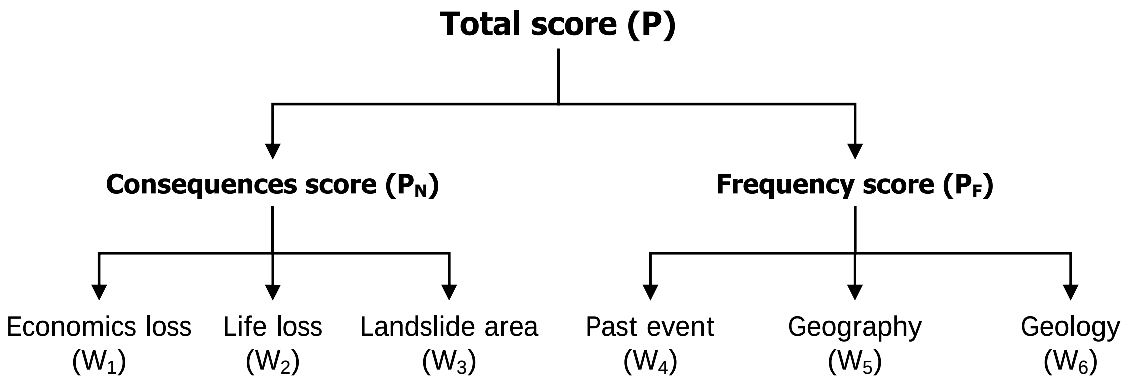


Figure 5 Element of total score

Figure 6 Example of scoring level for consequence factor of infra-structure damages

6. Ranking results

The 220 locations of previous and existing landslide were scored and weighted in order to obtain consequence and likelihood score of each location. Plotting between consequence and likelihood score were done for 220 locations of landslide. The ranking were done based on the assumption that the higher consequence and the likelihood score the more risky the area is. The method works like F-N chart technique. The chart was then classified in to three zones which are a high, medium and low risk area. All three cases were then plotted as shown in Fig. 7- Fig. 9. Each case is based on the purpose of a decision maker that will be concern more in economics or loss of life or both. Fig. 10 shows the first 20 risk areas. It can be seen that those 20 areas are all situated in Phuket Island. It also shows that most of the landslide occurred was triggered by slope cutting instead of natural event. Then, 7 locations out of 220 were selected in order to perform detail investigations and analyses.

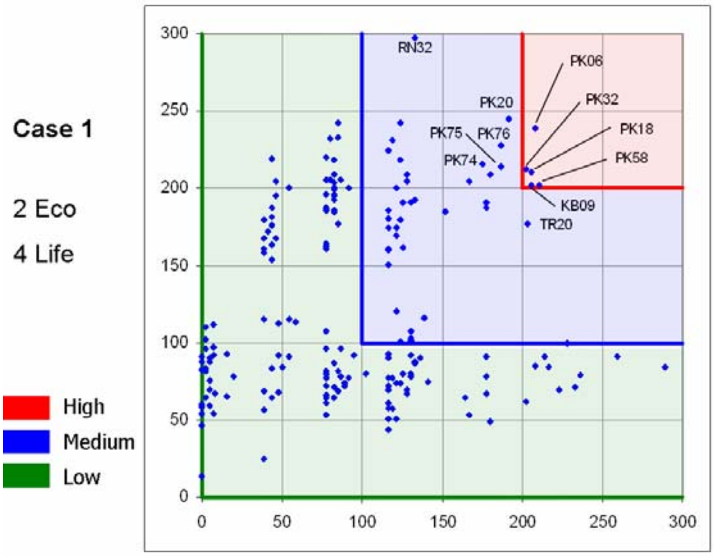


Figure 7 Ranking result of case 1

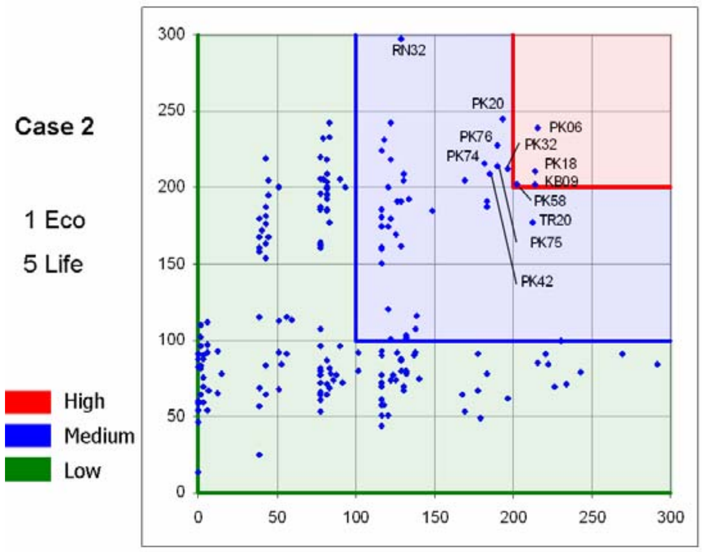


Figure 8 Ranking result of case 2

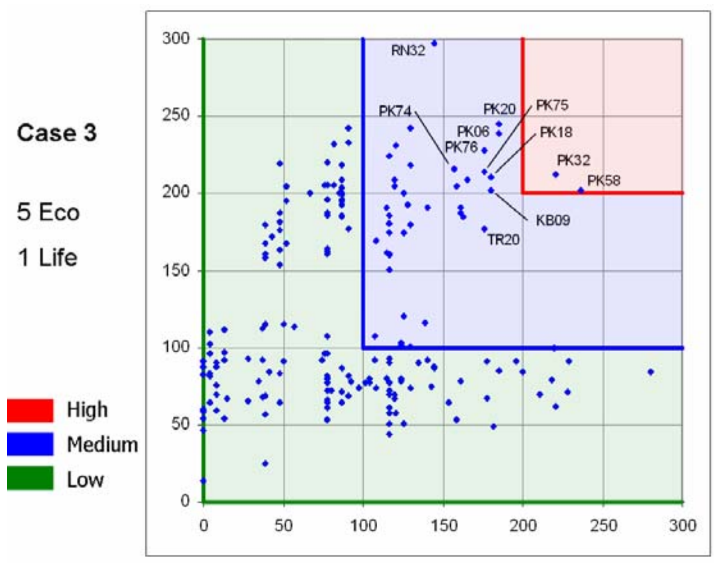


Figure 9 Ranking result of case 3

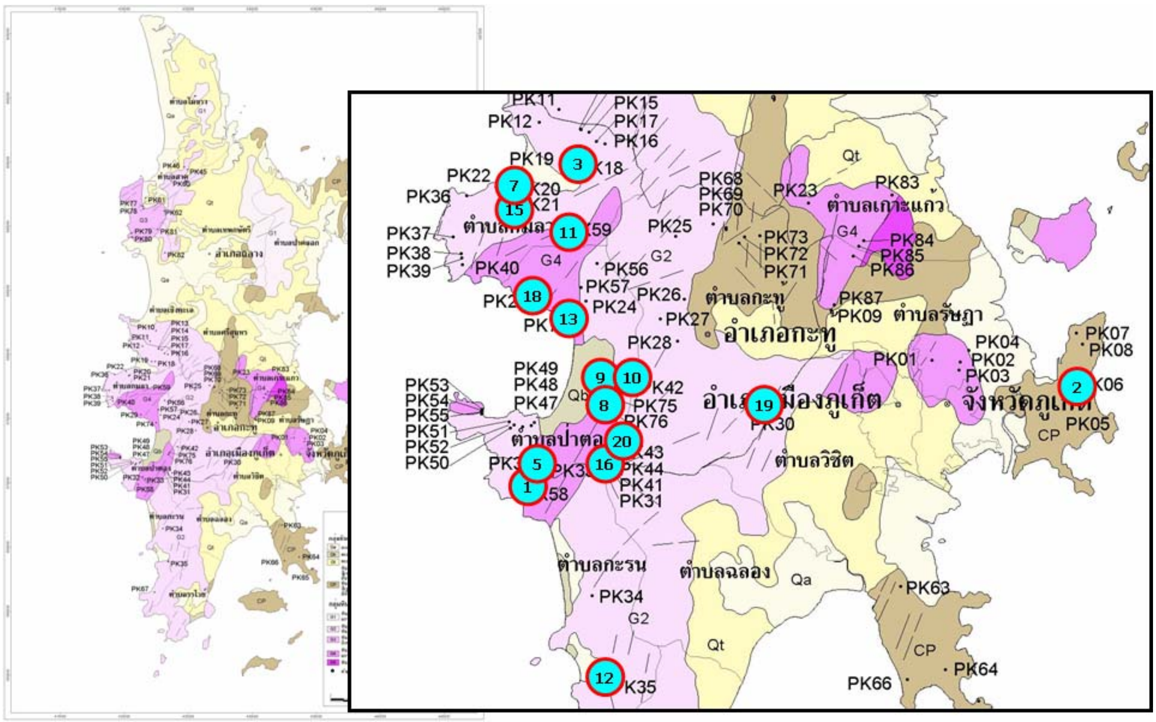


Figure 10 Landslide hazard areas in Phuket Island

7. Laboratory test

118 undisturbed soil samples were collected and tested by conventional direct shear machine. Two types of test had been done including strength reduction index test and multi degree of saturation-multistage direct shear test (KU-MDS shear test). The later tests were done only in selected areas in order to back analyst the event using the rainfall data. The prior tests were done in order to study characteristics of residual soil weathered from various rock types. The test were designed to be rather quick and easy by testing the shear strength of soil sample at its natural water content and comparing with the shear strength obtained from 24 hours saturated soil sample. The reduction of undrained shear strength due to saturation was called

strength reduction index. Fig. 11 shows the example of test result. Several granitic soil were tested, the results revealed that the granitic soil in these 6 provinces has tendency of up to 40 percent strength reduction (Fig 12).

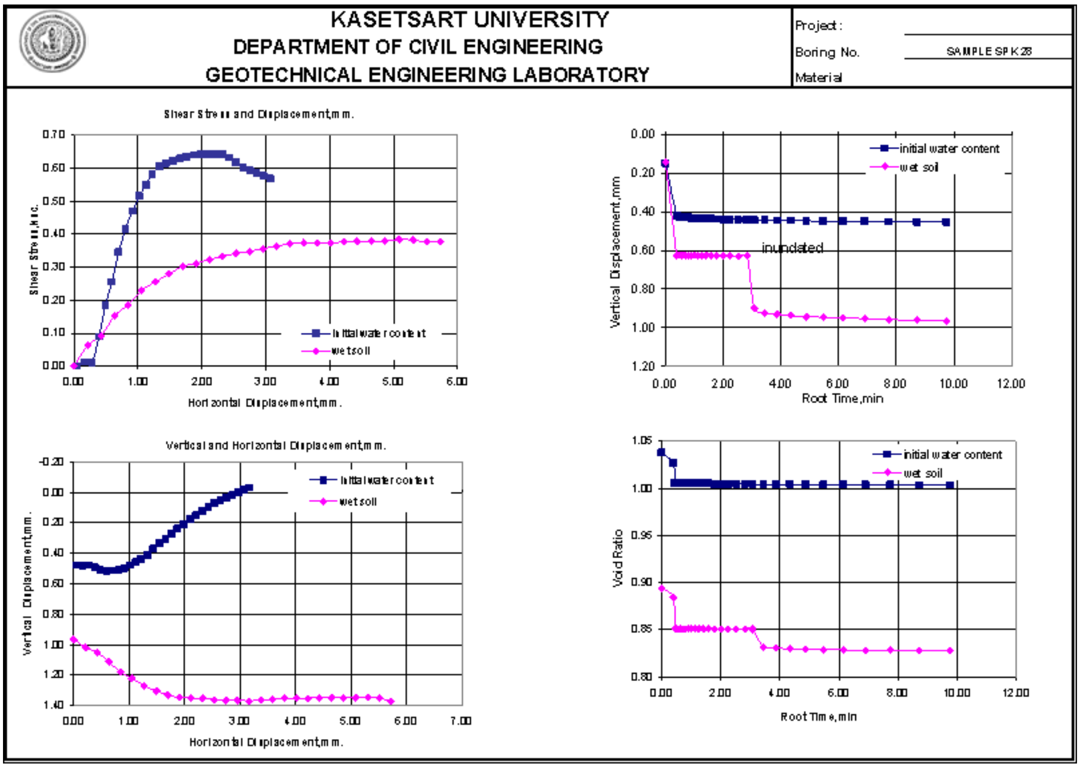


Figure 11 Example of the results of direct shear test for strength reduction index

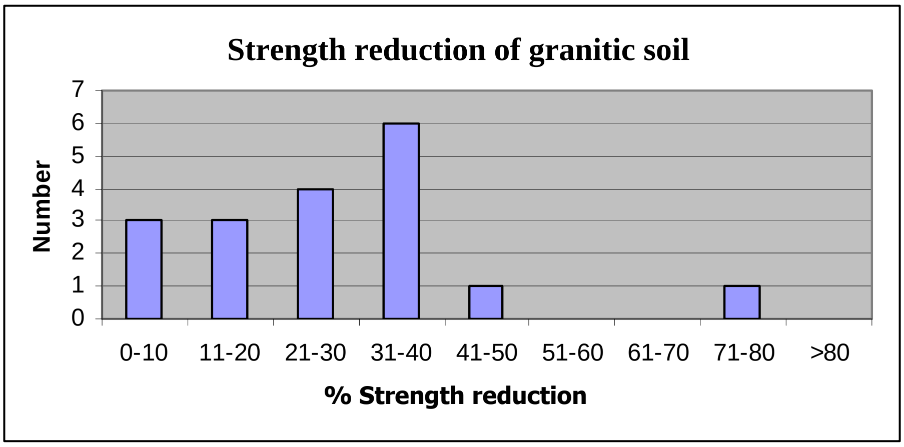
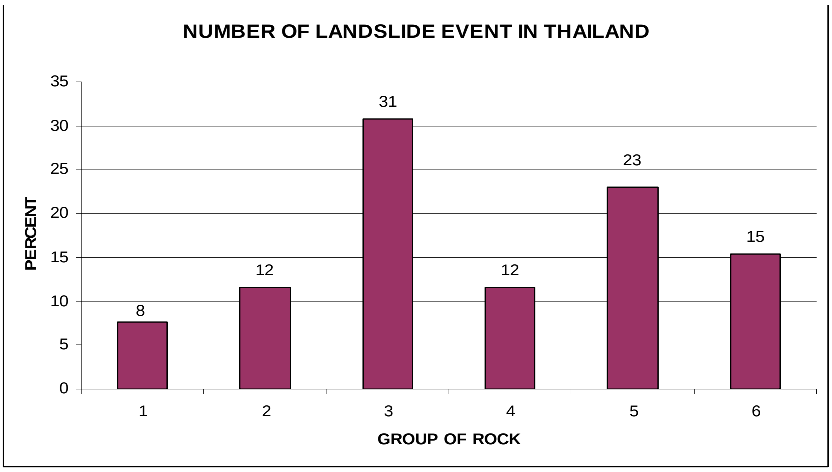


Figure 12 Percent of shear strength reduction of granitic soil in 6 provinces

8. Conclusion

Landslide hazard risk prioritization of 220 previous and existing landslide areas was done using weighting factor method and F-N chart technique. The method is rather simple but requires expert opinion or statistical data to support the weighting process. The ranking results found that Phuket Island is the most risky area to landslide. This is because the island rock formation is granite and pebbly mudstone which are rocks that statistically have high tendency of landslide in Thailand (Fig 13). Despite the fact that Phuket is one of the most attractive cities for tourist in the world, that even makes Phuket to be more vulnerable to landslide.



Group 1 Permo-Carb. granite
Group 2 Jurassic-Cretaceous granite
Group 3 Jurassic granite
Group 4 Volcanic and other plutonic rock
Group 5 Sandstone, shale, mudstone, conglomerate and chert
Group 6 Metamorphic rock

Figure 13 Landslide events in Thailand classified by rock group

9. Acknowledgements

The author would like to thank Department of Mineral Resources for cooperative project provided to Geotechnical Engineering Research and Development Center.

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