Landslide Risk Prioritization in 6 Provinces Affected by Tsunami

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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 caused economics and life losses. In order to manage the land properly after tsunami incident, landslide hazard zoning need to be done. Department of mineral resources in corporation with Geotechnical Engineering Research and Development Center (GERD), Kasetsart University is responsible in the project of developing landslide hazard map in 6 provinces affected by Tsunami. One of the important analyses that need to be made is prioritization the previous and existing landslide hazard area. 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.

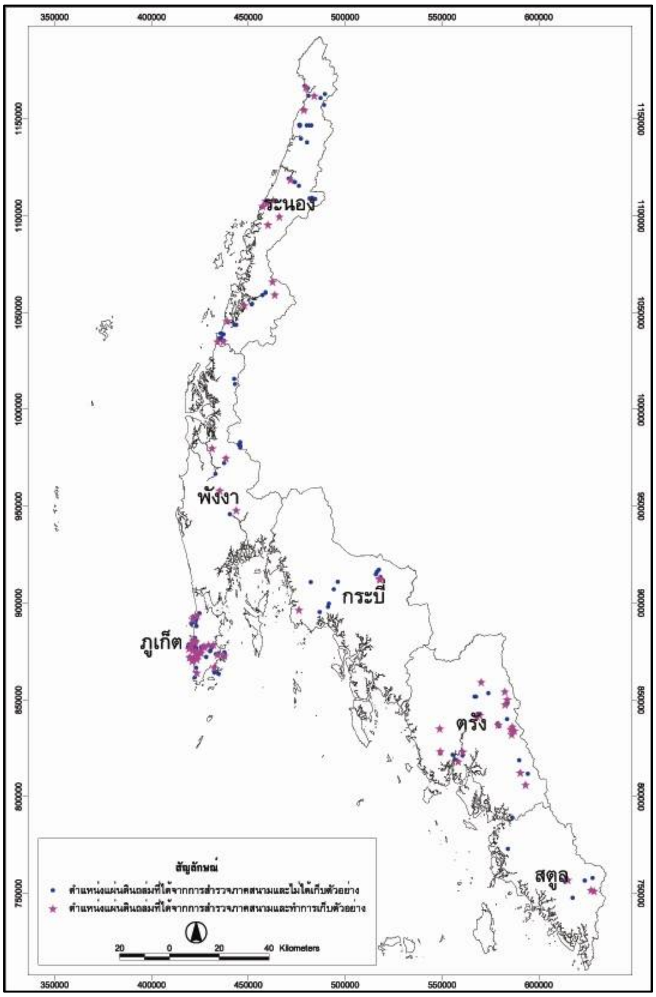

Figure 1 Study area

Factors considered

As indicated above, 220 locations of previous and existing landslide were investigated. In order to perform landslide risk prioritization, the following factors were considered.

1. Loss of life
2. Economics loss
3. Past event
4. Geographic
5. 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 is also has minor factors. Therefore, the 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 building
    b. Official building and transportation route
    c. Hotel and tourist attractions
3. Past event
    a. Number of past event
    b. Type of landslide (natural or man made)
    c. Size of landslide
4. Geographic
    a. Slope angle
    b. Distance from landslide to nearest village
    c. Watershed area
5. Geology
    a. Rock type
    b. Clay mineral content
    c. Joints and fractures content
    d. Present of fault
    e. Degree of weathering

Landslide Risk prioritization by weighting factor method

Weighting factor method was used to calculate risk score or risk index in order to rank the landslide hazard area. 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 give score from 1 to 5 which range from the most important to the least important. The major factors were weighted through the matrix as shown in Table 1 and Fig 2. The weighting procedure was done for minor factors as well. The conclusion of weight is shown in Table 2 and Fig 3.

Table 1 Weighting process for major factors

Major factors		1 Past Event	2 Life loss	3 Economic loss	4 Geography	5 Geology	Total score	In percentage (%)
1	Past event	-	1	2	3	2	8	13.3
2	Life loss	5	-	5	5	5	20	33.3
3	Economics loss	4	1	-	4	4	13	21.7
4	Geography	3	1	2	-	4	10	16.7
5	Geology	4	1	2	2	-	9	15.0

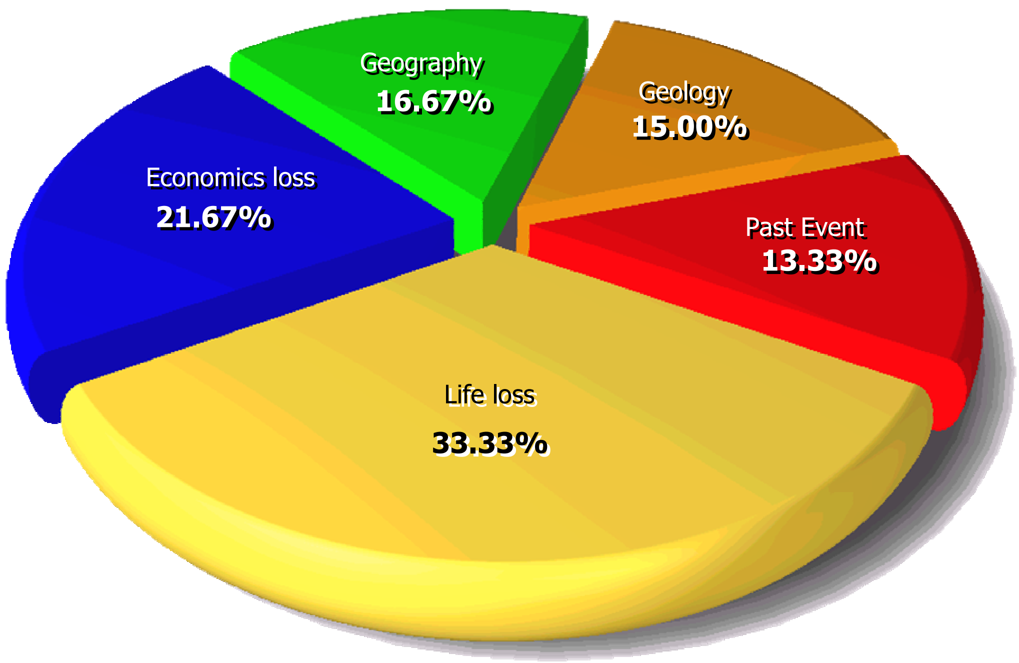

Figure 2 Weight of major factor in percentage

Table 2 Summary of weight of major and minor factors

	Major Factors	Major Weight (%)	Minor Factors	Minor Weight (%)	Adjusted weight (%)
1	Past event	13.3	Number of past event	33.3	**4.4**
			Type of landslide	44.5	**5.9**
			Size of landslide	22.2	**3.0**
2	Life loss	33.3	Number of village downslope	100.0	**33.3**
3	Economics loss	21.7	Number of residential building	38.9	**8.4**
			Official building and road	11.1	**2.4**
			Hotel and torious attractions	50.0	**10.8**
4	Geography	16.7	Slope angle	38.9	**6.5**
			Diatance from landslide the nearest village	27.8	**4.6**
			Watershed area	33.3	**5.6**
5	Geology	15.0	Rock type	15.0	**2.3**
			Clay mineral content	15.0	**2.3**
			joint and fractures content	26.7	**4.0**
			Present of fault	13.3	**2.0**
			Degree of weathering	30.0	**4.5**
Total		100.0		500.0	**100.0**

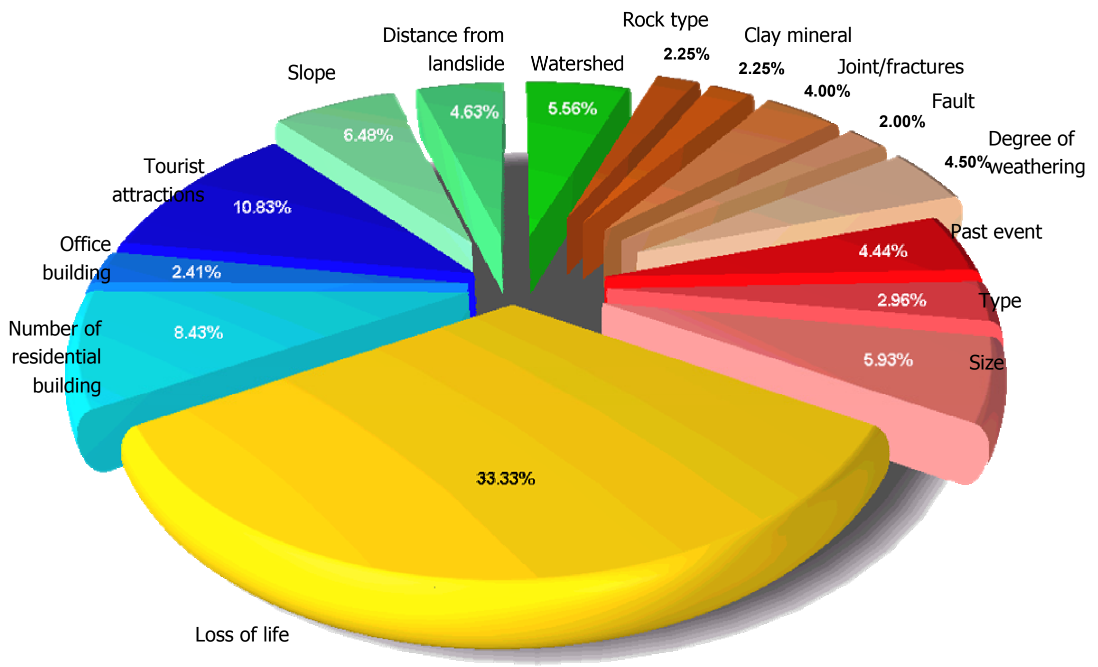

Figure 3 Weight of major and minor factors

<u>Scoring</u>

Fig. 4 shows how scoring was done. The scores were assigned to various conditions of minor factors. Data from field investigation were used to explain the range of conditions of each minor factor. The example of score for distance and flow path factor is shown in Fig 5.

$$\Sigma P = W_1[(W_{1\text{-}1}*P_{1\text{-}1})+(W_{1\text{-}2}*P_{1\text{-}2})+(W_{1\text{-}3}*P_{1\text{-}3})]+ W_2[(W_{2\text{-}1}*P_{2\text{-}1})]+ W_3[(W_{3\text{-}1}*P_{3\text{-}1})+ \ldots +W_5[(W_{5\text{-}1}*P_{5\text{-}1})+(W_{5\text{-}2}*P_{5\text{-}2})+(W_{5\text{-}3}*P_{5\text{-}3})+ (W_{5\text{-}4}*P_{5\text{-}4})+(W_{5\text{-}5}*P_{5\text{-}5})]$$

Figure 4 Equation used in weighting factor method

Figure 5 Example of scoring for distance and flow path factor

Ranking results

220 locations of previous and existing landslide were scored and weighted in order to obtain risk score of each location. Part of results is shown in Table 3. Fig. 6 shows the first 20 risk area. 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. 7 out of 220 locations were selected in order to perform detail investigations and analyses.

Table 3 Result of landslide risk prioritization

ตำแหน่ง	สถานที่	ปัจจัยการให้คะแนน															รวมคะแนน (จากการคำนวนคะแนนถ่วงน้ำหนัก)	ลำดับพื้นที่สำคัญ
		ประวัติของการเกิดดินถล่ม	ชนิดของดินถล่ม	ขนาดของดินถล่ม/รอยเปิด	จำนวนประชากรที่อาจได้รับผลกระทบ	จำนวนอาคารที่พักอาศัย	สถานที่ราชการ ถนน	แหล่งท่องเที่ยว โรงแรม	ความลาดชันของพื้นที่ที่เกิดดินถล่ม	ระยะทางจากดินถล่มถึงหมู่บ้าน และลักษณะเส้นทางการไหล	พื้นที่รับน้ำ	ชนิดของหิน	ส่วนประกอบของแร่ดินเหนียว	รอยแยก/รอยแตก	รอยเลื่อน	ระดับการผุพัง		
SPK09	ถนนเลี่ยงเมือง บริเวณที่มีการตัดลาดดิน	0	3	0	3	3	3	2	3	3	0	3	2	2	0	2	224.64	1
SPK04	หมู่บ้านร่มไม้ ซ.ชูจิตร บ้านกู้กู	0	2	0	3	3	2	1	3	2	0	2	2	3	0	3	210.06	2
SPK20	**ถนนรอบเกาะช่วงกมลา-ป่าตอง บริเวณ Rock Gabion**	**3**	**2**	**3**	**2**	**2**	**3**	**1**	**3**	**3**	**0**	**2**	**3**	**2**	**0**	**3**	**204.69**	**3**
SPK03	หลังบ้านพักตำรวจ ใกล้ร้านขายต้นไม้ บ้านกู้กู	1	2	0	3	1	2	0	3	3	0	2	2	3	0	3	191.44	4
SPK75	ด้านล่างถนน 50 ปี	1	2	3	2	2	1	1	3	3	0	1	2	2	3	2	187.99	5
SPK76	**ด้านล่างถนน 50 ปี ใกล้กับอพาร์ตเมนต์**	**1**	**2**	**3**	**2**	**2**	**1**	**1**	**3**	**3**	**0**	**1**	**2**	**2**	**3**	**2**	**187.99**	**5**
SPK02	ร้านขายต้นไม้ บ้านกู้กู	0	2	0	3	2	2	0	2	2	0	2	2	3	0	3	184.31	7
SPK58	ข้างโรงแรม Le Meridian	1	3	3	1	2	2	3	3	3	0	3	3	2	0	2	182.44	8
SPK06	**บ้านที่มีดินถล่มใส่จนบ้านพัง บริเวณเกาะสิเหร่**	**3**	**3**	**3**	**2**	**1**	**2**	**0**	**3**	**3**	**0**	**1**	**2**	**3**	**0**	**2**	**180.99**	**9**
SPK42	บ้านหลังคาสีน้ำเงิน ถนน 50 ปี	1	2	3	2	1	2	1	3	3	0	1	3	2	0	2	178.22	10
SPK74	**บ้านกะหลิม ซอยบารมี 6**	**1**	**2**	**3**	**2**	**2**	**1**	**0**	**3**	**3**	**0**	**3**	**3**	**2**	**0**	**2**	**177.91**	**11**
SPK18	ด้านบนที่พักคนงาน หลังภูเก็ตแฟนตาซี	1	3	3	2	1	1	0	3	3	0	2	3	2	0	3	174.69	12
SPK32	**เสา DTAC ระหว่างทาง ป่าตอง-กะรน**	**2**	**3**	**3**	**1**	**2**	**3**	**2**	**3**	**2**	**0**	**2**	**2**	**2**	**0**	**2**	**169.33**	**13**
SPK22	ข้างถนนทางไปโรงแรม Andara กมลา	0	3	0	2	0	2	3	2	3	0	2	3	2	0	2	167.97	14
SPK35	บริเวณบ้านกะตะ	1	2	3	2	2	2	0	3	3	0	2	2	1	0	1	167.31	15
SPK59	บริเวณฝายบางหวาน	1	2	3	2	2	2	0	3	2	0	2	2	1	0	2	167.19	16
หมายเหตุ	*พื้นที่สำคัญคัดเลือกใน จังหวัดภูเก็ต*																	
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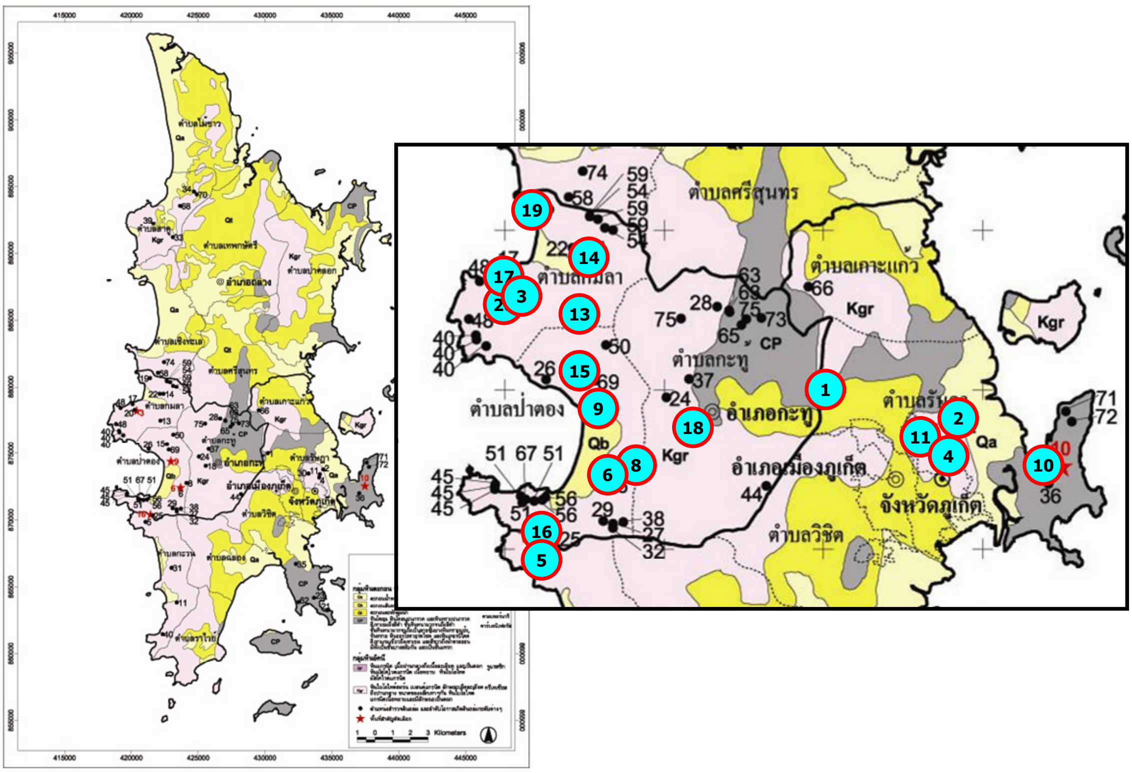

Figure 6 Landslide hazard areas in Phuket Island

<u>Laboratory test</u>

118 undisturbed soil samples were collected and tested by conventional direct shear machine. Two types of test have 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 area in order to back analysis the event using the rainfall data. The prior tests were done in order to study the characteristic of residual soil weathered from various rock type. The test were designed to be rather quick and easy by testing the shear strength of soil sample at its natural water content and compare with the shear strength obtain from 24 hours saturated soil sample. The reduction of undrained shear strength due to saturation is called strength reduction index. Fig. 7 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 less than 40 percent strength reduction (Fig 8).

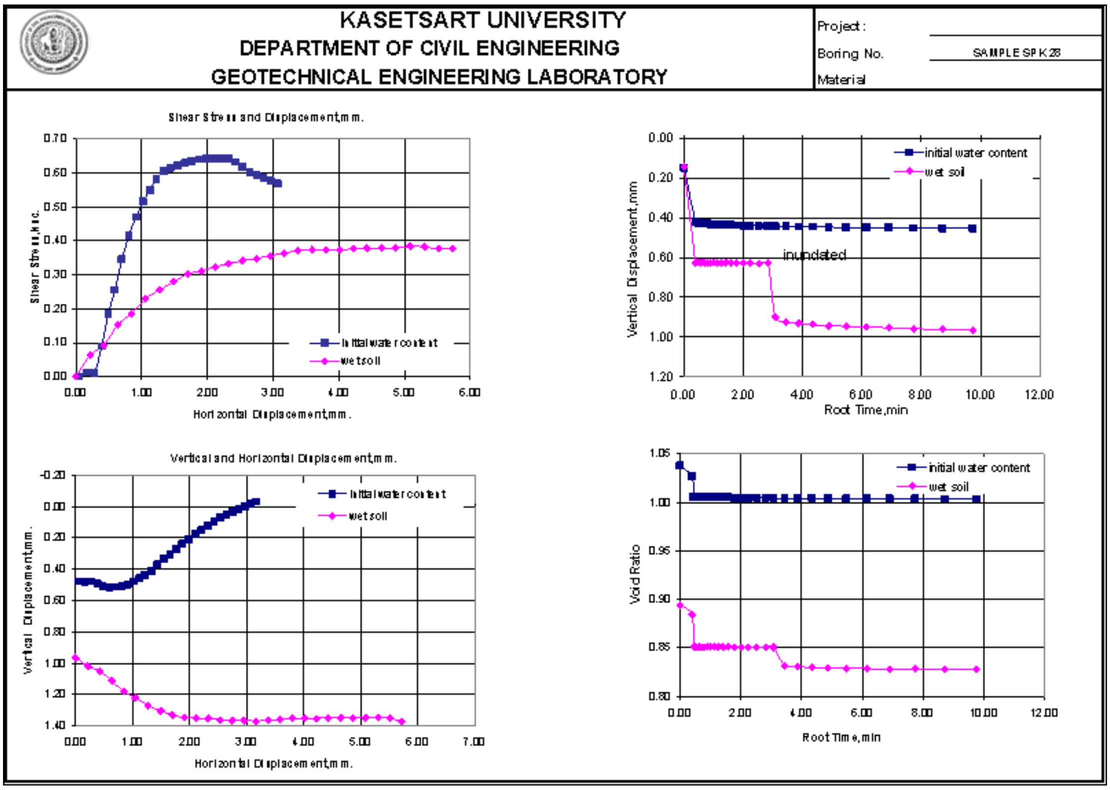

Figure 7 Example of the results of direct shear test for strength reduction index

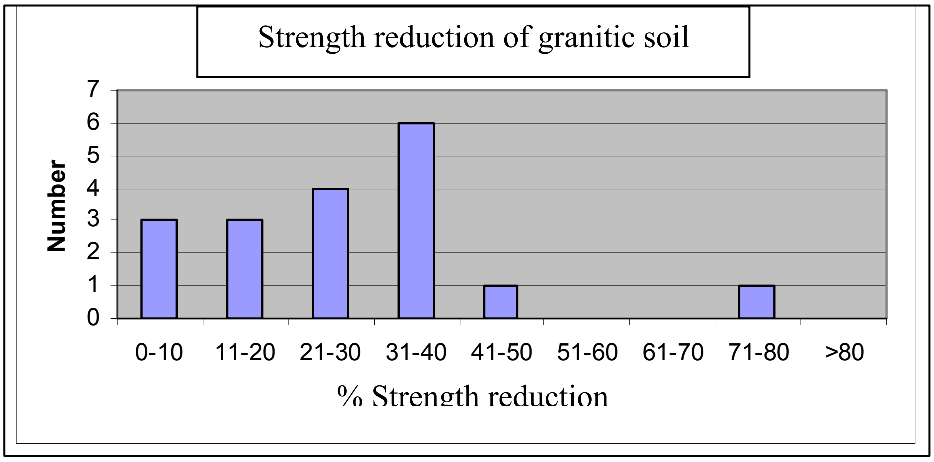

Figure 8 Percent of shear strength reduction of granitic soil in 6 provinces

Conclusion

Landslide hazard risk prioritization of 220 previous and existing landslide areas was done using weighting factor method. 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 of the island formed by granite and pebbly mudstone which are the rock that is statistically high tendency of landslide in Thailand (Fig 9). Despite the fact that Phuket is one of the most attractive city for tourist in the world, that is even make Phuket to be more vulnerable to landslide.

Acknowledgements

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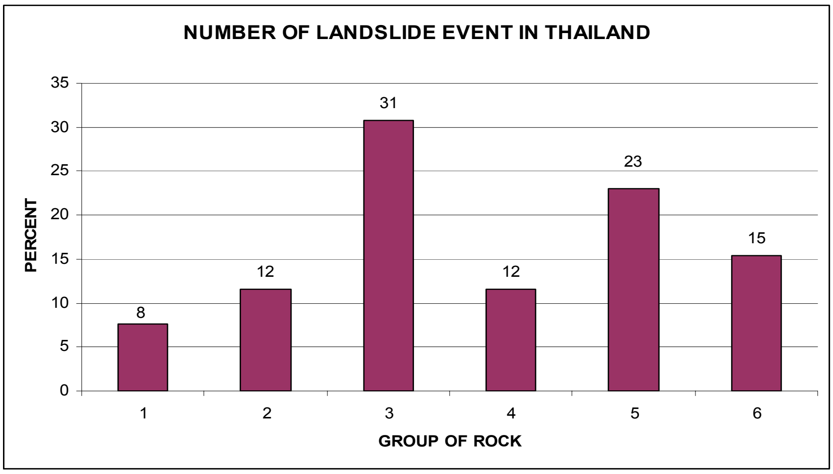

Group 1 Permo-Carb. granite
Group 2 Jurassic-Cretaceous granite
Group 3 Jurassic granite
Group 4 Volcanic and other plutonic rock
Group 5 Sandstone, shale, mudstone, conglomerate and chert
Group 6 Metamorphic rock

Figure 9 Landslide events in Thailand classified by rock group