Slope stability analysis of southern Ban Mae Sa Noi Area, Pong Yaeng Subdistrict, Mae Rim District, Chiang Mai Province

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Introduction

Northern Thailand, particularly the mountainous terrain of Chiang Mai Province is highly susceptible to landslides during periods of heavy rainfall. This poses a significant risk to communities like southern Ban Mae Sa Noi, where residential and agricultural areas are situated along steep valley slopes. To establish a crucial baseline for disaster monitoring and management, this study investigates the engineering properties of the local soil and evaluates overall slope stability to understand the region's landslide vulnerability better.

Abstract

The northern of Thailand, particularly Chiang Mai Province, is characterized as mountainous terrain and steep slopes, making it highly susceptible to landslides during periods of heavy rainfall. Southern Ban Mae Sa Noi in Pong Yaeng Subdistrict, Mae Rim District, is a residential and agricultural area located on steep valley slopes. Therefore, evaluating slope stability and investigating the engineering properties of the soil in this area is crucial to provide a baseline for disaster monitoring and management. This study aims to investigate the engineering properties of the soil and evaluate the stability of the slopes. Fieldwork was conducted to collect soil samples from 14 locations to determine physical properties, including grain size distribution, Atterberg limits, Unified Soil Classification System (USCS) classification, and shear strength, as well as in-situ soil permeability testing. The obtained parameters were then utilized to construct a slope stability model using GEO5 software, ranging from to calculate the factor of safety under five varying degrees of water saturation 10%, 30%, 50%, 70%, and 90%. The results revealed that the soil in the study area is classified under USCS as poorly graded silty sand with very poor drainage properties. The soil exhibited an average liquid limit of 44.25%, an average plastic limit of 35.88%, and an average plasticity index of 8.37%. Furthermore, the average cohesion was 0.57 t/m^2, the average internal friction angle was 29.43 degrees, and the in-situ permeability coefficient was extremely low at 2.43x10^{-6} cm/s. Regarding the slope stability simulation, the representative area S-MSN-1 yielded a factor of safety of less than 1.0 across all degrees of water saturation, indicating critically low stability and a consistently high risk of landslides. Conversely, the representative area S-MSN-2 maintained stability at water saturation levels between 10% and 70%; however, as the saturation level increased to 90%, the factor of safety dropped below 1.0, rendering the area highly prone to landslides. This analysis suggests that water accumulation in poorly drained soil layers is a primary factor contributing to the reduction in slope stability, thereby increasing the likelihood of landslide occurrences in the study area.

Study Area

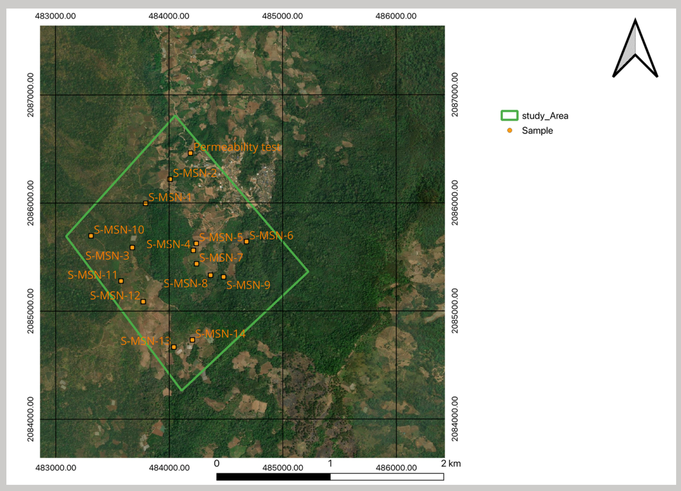


fig 1 Soil sampling locations

Objective

To study the physical properties of soil, including soil particle size, soil moisture content, and soil shear strength, to analyze the slope stability in the area of southern Ban Mae Sa Noi, Pong Yaeng Subdistrict, Mae Rim District, Chiang Mai Province.

Medthodology

1A Sampling

Collection of 14 soil samples from the study area.

1B Field Testing

In-situ soil permeability testing.

2 Laboratory Testing

Analysis of particle size distribution, Atterberg limits, and shear strength using the direct shear test.

3. Slop Stability Analysis

slope stability analysis using GEO5 software based on Bishop's Simplified method.

Results

Location 1 (S-MSN-1): The Factor of Safety (F.S.) is less than 1.0 at all water saturation levels, indicating a very high risk of landslides under all conditions.

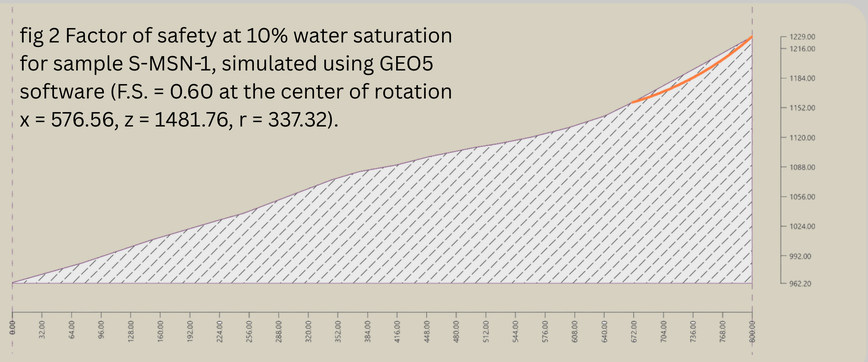


fig 2 Factor of safety at 10% water saturation for sample S-MSN-1, simulated using GEO5 software (F.S. = 0.60 at the center of rotation x = 576.56, z = 1481.76, r = 337.32).

Location 2 (S-MSN-2): The F.S. is 1.36 at water saturation levels from 10% to 70% (indicating stability). However, when water saturation increases to 90%, the F.S. drops to 0.89, indicating a risk of landslides

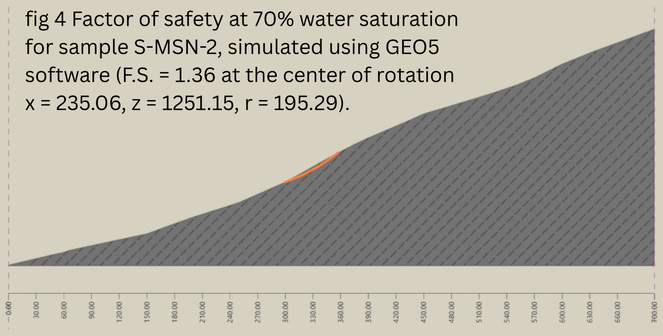


fig 4 Factor of safety at 70% water saturation for sample S-MSN-2, simulated using GEO5 software (F.S. = 1.36 at the center of rotation x = 235.06, z = 1251.15, r = 195.29).

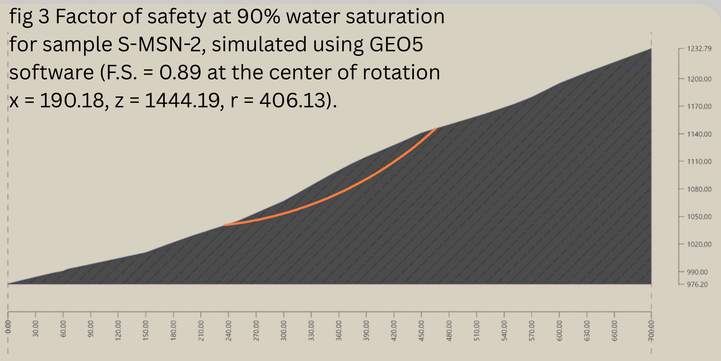


fig 3 Factor of safety at 90% water saturation for sample S-MSN-2, simulated using GEO5 software (F.S. = 0.89 at the center of rotation x = 190.18, z = 1444.19, r = 406.13).

Soil Properties

Grain size analysis

ตัวอย่างที่	ผลการคัดขนาด (ร้อยละ)			C_U	C_C
	กรวด	ทราย	ทรายแป้ง,ดินเหนียว		
S-MSN-1	21.80	69.47	8.73	8.32	1.50
S-MSN-2	1.37	88.87	9.76	13.34	1.54
S-MSN-3	0.30	77.30	22.40	15.82	0.19
S-MSN-4	5.09	88.67	6.24	7.06	0.78
S-MSN-5	3.90	85.94	10.16	11.30	0.62
S-MSN-6	1.55	95.17	3.28	4.87	1.42
S-MSN-7	1.46	75.90	22.63	7.69	0.08
S-MSN-8	2.46	89.04	8.50	8.25	0.60
S-MSN-9	2.04	91.49	6.46	6.79	0.57
S-MSN-10	2.52	87.73	9.75	11.18	0.81
S-MSN-11	7.58	85.20	7.21	9.42	0.86
S-MSN-12	2.40	92.82	4.78	5.64	0.85
S-MSN-13	16.32	74.92	8.74	15.11	2.36
S-MSN-14	4.84	83.12	12.0	12.44	0.55
เฉลี่ย				9.80	0.91

โดยที่ สัญลักษณ์ บ้านแม่สานน้อยตอนใต้ (S-MSN)

Atterberg's limit

ตัวอย่าง	พิกัดเหลว (ร้อยละ)	พิกัดพลาสติก (ร้อยละ)	ดัชนีพลาสติก (ร้อยละ)	ชนิดดิน (จำแนกแบบ USCS)
S-MSN-1	31.88	28.22	3.66	SM
S-MSN-2	36.99	33.20	3.79	SM
S-MSN-3	42.79	42.40	0.39	SM
S-MSN-4	39.42	38.71	0.72	SM
S-MSN-5	40.00	37.03	2.97	SM
S-MSN-6	43.64	40.19	3.45	SM
S-MSN-7	35.90	32.14	3.75	SM
S-MSN-8	102.56	42.04	60.52	SM
S-MSN-9	37.56	35.70	1.85	SM
S-MSN-10	47.31	42.40	5.27	SM
S-MSN-11	42.62	38.21	4.41	SM
S-MSN-12	44.68	37.64	7.04	SM
S-MSN-13	35.07	29.21	5.86	SM
S-MSN-14	41.54	31.93	9.61	SM
เฉลี่ย	44.25	35.88	8.37	SM

โดยที่ สัญลักษณ์ บ้านแม่สานน้อยตอนใต้ (S-MSN)

Direct shear test

S-MSN-7	1	7.08	3.58	38.65	0
	2	12.64	8.20		
	3	18.19	12.47		
S-MSN-8	1	7.08	1.17	33.98	0
	2	12.64	5.24		
	3	18.19	9.074		
S-MSN-9	1	7.08	6.728	25.53	2.93
	2	12.64	8.148		
	3	18.19	12.037		
S-MSN-10	1	7.08	4.074	37.67	0
	2	12.64	7.962		
	3	18.19	12.654		
S-MSN-11	1	7.08	2.839	31.19	0
	2	12.64	6.790		
	3	18.19	9.567		
S-MSN-12	1	7.08	3.333	15.22	1.60
	2	12.64	5.432		
	3	18.19	6.358		
S-MSN-13	1	7.08	2.839	20.41	0.48
	2	12.64	5.740		
	3	18.19	6.975		
S-MSN-14	1	7.08	3.024	18.72	0.71
	2	12.64	5.185		
	3	18.19	6.790		
เฉลี่ย				29.43	0.57

โดยที่ สัญลักษณ์ บ้านแม่สานน้อยตอนใต้ (S-MSN)

Conclusion

- The area predominantly consists of Silty sand with very poor drainage capabilities
- The High-Risk Area (Sample S-MSN-1): The slope here is highly unstable. It is at a constant risk of a landslide, no matter how dry or wet the soil is.
- The Rain-Dependent Area (Sample S-MSN-2): The slope here is generally safe under normal conditions. However, if there is heavy rain and the soil becomes heavily soaked with water (reaching 90% saturation), it becomes extremely unstable and dangerous.

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