Slope Stability Analysis at North of Ban Mae Sa Noi, Pong Yaeng Subdistrict, Mae Rim District, Chiang Mai Province

Author: Nantaphong Chommala 650510441 Advisor: Asst. Prof. Dr. Nipada Santha
Department of Geological Sciences, Faculty of Science, Chiang Mai University

Abstract

Landslides pose a significant threat to life and property, particularly in steep mountainous areas experiencing land-use changes. The northern region of Ban Mae Sa Noi in Pong Yaeng Subdistrict, Mae Rim District, Chiang Mai Province, is considered highly vulnerable to such hazards due to its steep topography, heavy monsoonal rainfall, and land-use changes that reduce root cohesion. This study aimed to investigate the physical and geotechnical properties of the local soils to evaluate slope stability. 14 soil samples were collected for laboratory testing to determine unit weight, moisture content, grain size distribution, Atterberg limits, shear strength, and permeability. The derived engineering parameters were utilized to assess slope stability using the Geo5 software under varying degrees of saturation ranging from 10% to 90%. Soil characterization revealed that the area predominantly consists of well-graded sand mixed with fine-grained particles, exhibiting low plasticity and very low permeability. This indicates poor drainage characteristics, potentially leading to critical pore water pressure buildup during heavy rainfall. The slope stability analysis demonstrated that while most surveyed areas exhibit safe factors of safety (FoS ranging from 1.72 to 6.93), certain locations (Slope 1 and N-MSN-11) present marginally stable to high-risk conditions of failure (FoS ranging from 0.59 to 3.51). These findings highlight the necessity for continuous monitoring and the implementation of appropriate landslide mitigation measures in the vulnerable zones.

Introduction

Landslides pose a severe threat to mountainous communities, primarily triggered by steep topography, heavy monsoonal rainfall, and land-use changes (Fig. 1) that reduce essential root cohesion. The Ban Mae Sa Noi area in Mae Rim District, Chiang Mai Province, exemplifies these high-risk conditions. To address this vulnerability, this study investigates the physical and geotechnical properties of local soils and performs comprehensive slope stability analyses. Ultimately, the research aims to pinpoint failure mechanisms, assess landslide risks, and establish actionable guidelines for future monitoring and mitigation in this highly susceptible region.



Fig. 1 Typical landscape of the study area showing steep slopes and recent landuse changes

Study Area

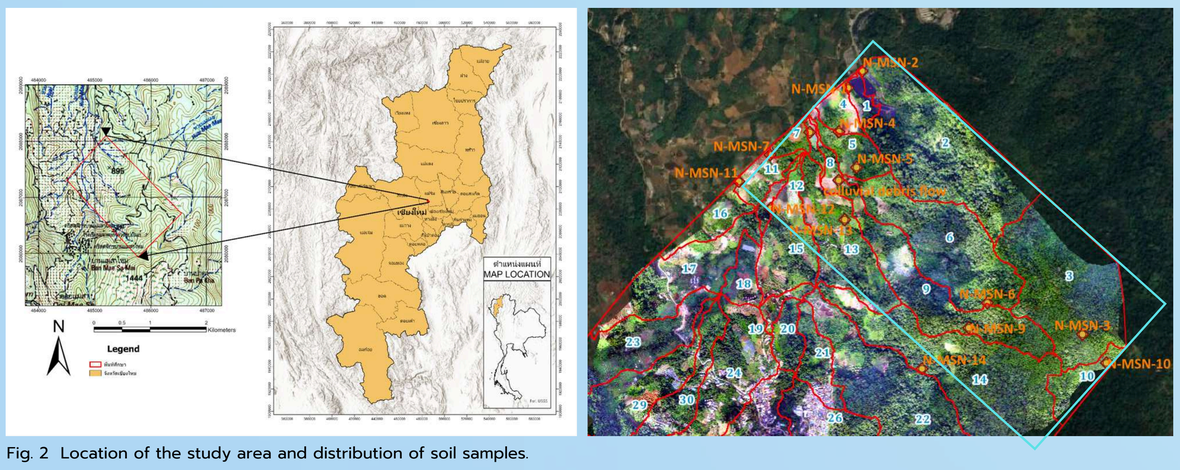


Fig. 2 Location of the study area and distribution of soil samples.

Objectives

- To investigate the physical and geotechnical properties of soils, including grain size distribution, moisture content, and shear strength.
- To evaluate the slope stability of the northern area of Ban Mae Sa Noi, Pong Yaeng Subdistrict, Mae Rim District, Chiang Mai Province

Methodology

1. Field Investigation

- Collected 14 soil samples from depths of 0.8 meters across the study area.
- Extracted soil cores using a slotter machine, wrapped tightly, and stored in sealed containers.
- Collected approximately 2 kg of disturbed soil in Ziploc bags.



Fig. 3 On-site Soil Collection

2. Laboratory Testing

Determined physical & geotechnical properties:

- Direct Shear Test (Cohesion & Internal Friction Angle)
- Grain Size Analysis (Sieve Analysis)
- Atterberg Limits (Liquid Limit, Plastic Limit, Plasticity Index)



Fig. 4 Geotechnical Lab Testing

3. Slope Stability Analysis

- Imported laboratory testing results as geotechnical parameters into Geo5 software
- Simulated 4 cross-sections using Bishop's Method
- Applied varying groundwater saturation levels (10% - 90%)

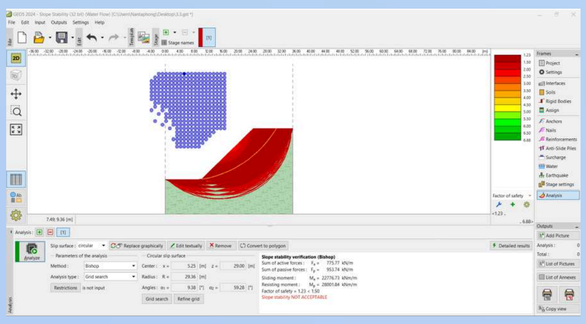


Fig. 5 Slope Stability Analysis using GEO5

Results

Direct Shear Test

จุดศึกษาที่	ครั้งที่	หน่วยแรงเฉือนสูงสุด (ksc)	หน่วยแรงเฉือนสูงสุด (ksc)	มุมเสียดทานภายใน	แรงยึดเหนี่ยวระหว่างอนุภาค
N-MSN-1	1	7.08	3.32	24.49	0.11
	2	12.64	5.49		
	3	18.19	8.58		
N-MSN-2	1	7.08	4.63	30.96	0.67
	2	12.64	8.83		
	3	18.19	11.30		
N-MSN-3	1	7.08	4.41	34.02	0.00
	2	12.64	9.20		
	3	18.19	11.91		
N-MSN-4	1	7.08	4.29	27.95	0.98
	2	12.64	8.58		
	3	18.19	14.19		
N-MSN-5	1	7.08	4.78	28.84	0.73
	2	12.68	7.19		
	3	18.19	10.80		
N-MSN-6	1	7.08	3.77	31.66	0.00
	2	12.64	7.62		
	3	18.19	10.62		
N-MSN-7	1	7.08	4.32	37.28	0.00
	2	12.64	8.55		
	3	18.19	12.76		
N-MSN-8	1	7.08	4.26	35.42	0.00
	2	12.64	8.58		
	3	18.19	12.16		
N-MSN-9	1	7.08	4.41	32.35	0.00
	2	12.64	7.93		
	3	18.19	11.45		
N-MSN-10	1	7.08	4.60	33.73	0.00
	2	12.64	9.51		
	3	18.19	12.19		
N-MSN-11	1	7.08	3.77	29.54	0.00
	2	12.64	6.56		
	3	18.19	10.06		
N-MSN-12	1	7.08	4.01	32.01	0.00
	2	12.64	6.79		
	3	18.19	10.96		
N-MSN-13	1	7.08	5.59	34.56	0.00
	2	12.64	7.56		
	3	18.19	10.74		
N-MSN-14	1	7.08	5.21	30.26	0.00
	2	12.64	5.59		
	3	18.19	9.69		
เฉลี่ย				31.76	0.18

Fig. 6 Direct Shear Result of Soil Samples

Grain Size Analysis

จุดศึกษาที่	ผลการคัดขนาด (%)			Cu	Cc
	กรวด	ทราย	ทรายแป้งปนดินเหนียว		
N-MSN-1	6.41	84.50	9.09	10.06	0.64
N-MSN-2	11.21	81.80	7.00	12.25	1.24
N-MSN-3	2.67	90.59	6.74	10.89	2.68
N-MSN-4	6.75	87.16	6.09	8.19	0.82
N-MSN-5	9.44	85.02	5.55	10.16	2.68
N-MSN-6	9.04	82.80	8.16	16.77	3.55
N-MSN-7	5.54	81.51	12.95	17.39	0.97
N-MSN-8	5.68	81.43	12.89	17.39	0.98
N-MSN-9	5.37	87.28	7.35	12.68	2.43
N-MSN-10	6.34	85.55	8.10	14.15	2.75
N-MSN-11	6.76	80.90	12.34	18.53	1.19
N-MSN-12	13.35	74.91	11.75	23.28	1.90
N-MSN-13	2.68	76.16	21.16	16.40	0.34
N-MSN-14	2.82	90.77	6.41	9.75	2.03
เฉลี่ย				14.14	1.73

Fig. 7 Grain Size Distribution of Soil Samples

Atterberg Limits

จุดศึกษาที่	พิกัดเหลว (ร้อยละ)	พิกัดพลาสติก (ร้อยละ)	ดัชนีพลาสติก (ร้อยละ)
N-MSN-1	42.09	28.89	13.20
N-MSN-2	44.85	28.04	16.81
N-MSN-3	50.72	36.82	13.90
N-MSN-4	53.85	41.64	12.21
N-MSN-5	52.75	40.74	12.02
N-MSN-6	47.30	42.54	4.76
N-MSN-7	41.86	28.61	13.26
N-MSN-8	45.04	23.86	21.18
N-MSN-9	39.87	31.36	8.51
N-MSN-10	42.03	34.07	7.95
N-MSN-11	25.32	20.92	4.41
N-MSN-12	26.63	22.53	4.10
N-MSN-13	32.78	36.76	0
N-MSN-14	34.47	40.74	0
เฉลี่ย	41.40	32.68	9.45

Fig. 8 Atterberg Limits of Soil Samples

- **Direct Shear**: Moderate friction angle, Low cohesion
- **Grain Size Analysis:** Mostly well-graded sand (SW), Predominantly sand
- **Atterberg's Limits:** Low plasticity, Low shrink-swell potential
- **Slope Stability Analysis:**
  - Slope 1 (South of Mae Sa Noi): Unstable, High risk ❌
  - Slope N-MSN-1: Stable / Safe ✅
  - Slope N-MSN-11: Moderate Risk ⚠️
  - Slope N-MSN-13: Stable / Safe ✅

Slope Stability Analysis

Slope no.	Degree of Saturation	Factor of safety (FoS)	
		Minimum	Maximum
1	10	0.59	1.26
	30		
	50		
	70		
	90		
N-MSN-1	10	2.33	6.93
	30		
	50		
	70		
	90		
N-MSN-11	10	1.29	3.51
	30		
	50		
	70		
	90		
N-MSN-13	10	1.72	5.23
	30		
	50		
	70		
	90		

Fig. 9 Factor of Safety from Slope Stability Analysis

Conclusions

The study reveals that the predominantly sandy soils with fine particles in Ban Mae Sa Noi have very low permeability, leading to critical pore water pressure buildup during heavy rainfall. While most slopes are generally safe (FoS: 1.72 – 6.93), specific high-risk zones like Slope 1 and N-MSN-11 become critically unstable (FoS: 0.59 – 3.51) under 90% water saturation. Continuous monitoring and the implementation of engineered landslide mitigation strategies are urgently required for these vulnerable areas.

References

- Department of Mineral Resources. (2015). Geological and mineral resources management zoning of Chiang Mai Province. Department of Mineral Resources.
- Department of Mineral Resources. (2021). Landslide susceptibility map of Thailand. Bangkok, Thailand: Ministry of Natural Resources and Environment.
- Saenton, J. (2021). Engineering Geology Course materials. Chiang Mai: Department of Geology, Faculty of Science, Chiang Mai University.