Evaluating Geotechnical Parameters for Geotourism Potential in Pukpui, Lunglei, Mizoram

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Abstract

This study explores the geotechnical characteristics of soil in Lunglei town, Mizoram, to evaluate its suitability for construction, infrastructural development, and potential geotourism initiatives. A comprehensive series of field and laboratory tests were conducted to analyze soil composition, shear strength, compaction properties, and bearing capacity. The findings indicate significant variations in soil types, with a predominance of clayey and silty soils, which directly impact stability and foundation requirements. Given Lunglei's hilly terrain, slope stability is a key concern, as soil properties influence erosion susceptibility and the feasibility of large-scale development. This research highlights potential geotechnical challenges in establishing Lunglei as a geotourism hub, including issues related to land stability, foundation support, and soil behavior under different loading conditions. Understanding these parameters is essential for designing safe, resilient, and sustainable infrastructure in the region. The study's outcomes provide valuable guidance for engineers, urban planners, and policy makers, ensuring that geotourism-related developments align with best geotechnical practices. By addressing soil-related constraints and recommending appropriate construction strategies, this research contributes to the long-term viability of Lunglei as a geotourism destination while promoting environmental sustainability and risk mitigation in infrastructure projects.

Keywords: *Geotechnical index parameters, Geotourism, Soil characteristics*

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Introduction

Lunglei, a scenic town in southern Mizoram, Northeast India, lies between 92º 42’ 45” E to 92º 50’ 05” E longitudes and 22º 48’ 18” N to 22º 56’ 55” N latitudes, as mapped in Survey of India sheets 84B/09 and 84B/13 (Survey of India, 2005). Known for its lush green hills, dense forests, and rich biodiversity, the town boasts breathtaking landscapes and unique geological formations (Lalchhandama, 2018). Its undulating terrain, interwoven with rivers and waterfalls, enhances its appeal for nature lovers and geotourism. With its ecological and scenic significance, Lunglei holds great potential for sustainable tourism and scientific exploration.

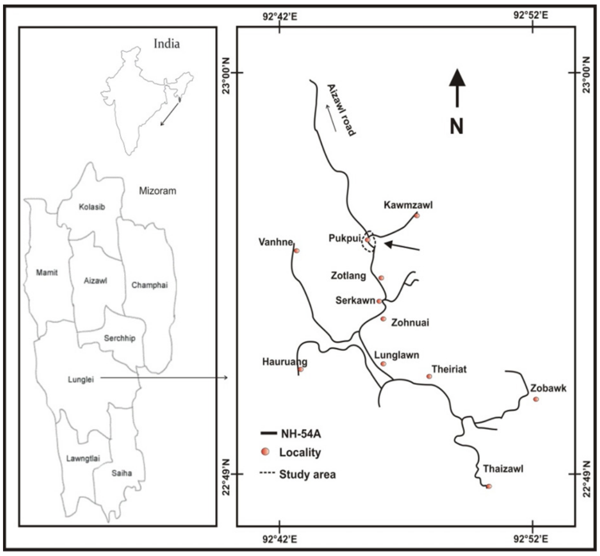

Fig No 1: Location of study area

Nestled amidst rolling hills and picturesque valleys, Lunglei boasts a captivating blend of natural beauty and serenity. Its location within the rugged terrain of the north-south trending Lushai Hills enhances its scenic appeal, offering dramatic landscapes shaped by steep slopes and verdant forests. The region is further enriched by pristine rivers, diverse flora, and abundant wildlife, making it a haven for biodiversity. Lunglei’s cool, temperate climate creates a refreshing atmosphere, making it an ideal retreat for visitors seeking peace and tranquility. With its breathtaking panoramic views and unspoiled natural surroundings, the town stands out as a perfect destination for eco-tourism, adventure enthusiasts, and those eager to explore Mizoram’s rich ecological and geological heritage.

Geology of Mizoram

Mizoram is geologically part of the Tripura-Mizoram accretionary belt, representing the southern extension of the Surma Basin, which formed due to the regional uplift of the Barail Group and was influenced by plate behavior in the subduction zone west of Arakan-Yoma during the Cenozoic era (Evans, 1964). The region consists of repetitive sequences of arenaceous and argillaceous sediments, including sandstone, siltstone, shale, mudstone, and occasional pockets of shell-limestone and intraformational conglomerates (Lalnuntluanga, Sangode & Meshram, 2012). These formations generally trend north-south (N-S) with dips varying between 20° and 50° towards the east or west. The Tertiary succession of Mizoram is classified into three major groups in ascending order: Barail Group (Oligocene), Surma Group (Lower to Middle Miocene), and Tipam Group (Upper Miocene to early Pliocene) (Barman & Rao, 2021). The Surma Group, covering most of the state, is further divided into Bhuban and Bokabil Formations, with the Bhuban Formation consisting of lower, middle, and upper units based on the ratio of argillaceous and arenaceous components (Bharali, 2019). Structurally, the Mizoram Hills (Lushai Hills) form part of a mobile belt with tight, elongated N-S trending anticlines alternating with broad synclines that exhibit slightly arcuate, westward convex trends. The resistant older rock units are predominantly exposed in the synclinal troughs, defining the rugged terrain of the region (Tiwari & Raj, 2012).

Rationale

Beneath Lunglei's stunning landscapes lie a complex and dynamic geotechnical framework that significantly influences its urban development. As the town undergoes rapid expansion and infrastructural growth, a thorough understanding of its soil characteristics and stability is crucial for ensuring safe and sustainable construction practices. The region's diverse terrain, coupled with heavy monsoon rainfall and occasional seismic activity, poses challenges in assessing soil strength, bearing capacity, and slope stability. These factors make geotechnical investigations essential to prevent risks such as landslides, foundation failures, and erosion. This study focuses on analyzing the geotechnical properties of soil in the Pukpui locality of Lunglei, providing valuable data to aid urban planners, engineers, and policymakers in making informed decisions for risk mitigation, sustainable growth, and environmental conservation.

The primary focus of this study is on the Pukpui area, located within Lunglei town, where comprehensive geotechnical investigations were conducted (Fig No 1). Various soil properties were analyzed through laboratory testing to assess their engineering behavior. The tests performed include the Liquid Limit, Plastic Limit, and Plasticity Index, which determine soil consistency and plasticity characteristics. Additionally, Proctor Compaction tests were carried out to evaluate the optimum moisture content and maximum dry density of the soil. The Direct Shear test was conducted to measure the soil's shear strength parameters, while the Safe Bearing Capacity of Soils was determined to assess their suitability for construction. These tests were performed at the Geotechnical Laboratory, Department of Geology, Lunglei Government College, as part of a research project funded by DST-SERB.

Review of related literature

Lallawmsanga, Christopher, Lalthazuala, (2023) conducted a study on the geotechnical characteristics of soils in the Saron Veng area of Aizawl, Mizoram. They performed tests to determine the Liquid Limit, Plastic Limit, and Plasticity Index, providing insights into the soil's consistency and plasticity. Additionally, Proctor Compaction tests were conducted to assess the optimum moisture content and maximum dry density, which are critical for understanding soil compaction behavior. The findings contribute to a better understanding of soil properties in landslide-prone areas.

Lallianthanga & Laltanpuia, (2019) examined the impact of various land use systems on soil properties in Mizoram. The study analyzed physical properties such as soil texture, bulk density, moisture content, and water-holding capacity, as well as chemical properties including pH, organic carbon, nitrogen, phosphorus, and potassium content. The findings highlight how different land use practices influence soil health and fertility in the region.

Vinoth, Prasad, Mathur & Kumar, (2022) focused on the geotechnical investigation of a landslide in the Hunthar area of Aizawl. The researcher conducted subsurface explorations, including borehole drilling and sampling, to determine the soil profile and properties. Laboratory tests such as grain size analysis, Atterberg limits, and direct shear tests were performed to assess the soil's engineering behavior. The study provides recommendations for remedial measures to stabilize the landslide-affected area.

Methodology

The methodology for conducting the geotechnical tests on soil samples from Pukpui locality in Lunglei town involves several standard procedures to assess key properties such as consistency, compaction and shear strength.

Liquid Limit Test: The liquid limit is determined using the Casagrande method. A soil sample is mixed with water, and the liquid limit is found by repeatedly cutting a groove in the soil and observing the water content at which the groove closes over a specified distance. This determines the soil's transition from liquid to plastic state.

Plastic Limit Test: For the plastic limit, soil is rolled into threads, and the water content at which the soil begins to crumble is recorded. This defines the boundary between the plastic and semi-solid states (ASTM D4318-17, 2017).

Plasticity Index: The plasticity index is calculated as the difference between the liquid limit and the plastic limit, providing insight into the soil's plasticity and behavior.

Proctor Compaction Test: The Proctor test is performed to determine the maximum dry density and optimum moisture content (Proctor, 1933). Soil samples are compacted in a standard mold at varying moisture contents, and the resulting dry densities are measured.

Direct Shear Test: To assess the shear strength, a direct shear test is conducted by placing the soil sample in a shear box and applying a normal load while monitoring the shear force required to cause failure.

Results and discussions

The results and discussions section presents a comprehensive analysis of the geotechnical tests conducted on soil samples from Lunglei town. These tests, including the liquid limit, plastic limit, plasticity index, Proctor compaction, and direct shear, provide essential data on the soil's consistency, compaction behavior, plasticity, and shear strength. Understanding these properties is crucial for assessing the soil's engineering suitability for construction, its stability under varying environmental conditions, and its response to external loads.

Furthermore, the discussion will interpret the findings in the context of Lunglei's unique topography and geological setting, highlighting key factors such as slope stability, settlement characteristics, and the influence of seasonal rainfall on soil behavior. Special emphasis will be placed on identifying potential geotechnical challenges associated with construction in the region and recommending appropriate measures to mitigate risks related to erosion, soil compaction, and foundation stability.

The Plasticity Index (PI) is calculated as:

PI = LL - PL = 33.50 - 22.41 = 11.09%. According to the BIS soil classification system (BIS, 1970), a PI value between 10-20% indicates inorganic clay of medium plasticity, suggesting moderate cohesion and compressibility. The Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) define the soil's compaction characteristics. A dry density of 1.80 g/cm^3 is typical for medium-plasticity clayey soils

(Das, 2013), while an OMC of 14% suggests that the soil requires a moderate water content to achieve maximum compaction, which enhances its stability in engineering applications (Murthy, 2017). The specific gravity (Gs) of 1.60 is relatively low, indicating the possible presence of organic content or lighter soil particles. Inorganic clays typically have Gs values between 2.6 and 2.75, so this result may suggest some unconventional soil characteristics. In terms of shear strength, the cohesion (C) of 0.130 kg/cm² is typical for medium-plasticity clays, providing moderate resistance against shear forces. The angle of shearing resistance (Φ) at 26.53° suggests reasonable load-bearing capacity but indicates the potential for moderate settlement under heavy loads. This classification confirms that the soil is suitable for moderate-load-bearing applications. However, due to its clayey nature, it may be susceptible to volume changes with moisture fluctuations, necessitating proper drainage measures in construction projects. The safe bearing capacity (SBC) of 19.25 T/m² is within an acceptable range for medium- to high-load structures, including low-rise buildings, pavements, and industrial floors. However, foundation design should account for potential settlement due to clay content. If high moisture content is expected, soil stabilization or deep foundation methods may be required (Table No 1).

Table No 1: Results of Geotechnical tests conducted

Sl.	Test	Unit	Sample	IS Code
1	Liquid Limit	%	**33.50**	IS: 2720 (Part 5)
2	Plastic Limit	%	**22.41**	
3	Plasticity Index	%	**11.09**	
4	**Proctor Compaction**			IS-2720 (Part-7)
	(i) Dry Density (Unit weight)	kg/cm2	**0.130**	
		T/m2	**1.27**	
	(ii) OMC	degree	**26.53**	
7	Type of soil	**Inorganic clay of medium plasticity**		BIS
8	**Safe Bearing Capacity of Soil**	T/m2	**19.25**	IS : 6403
		kN/m2	**188.80**	

Table No 2: Plasticity Index

Characteristics of Soils With Different Plasticity Index (Coduto, 1999 Modified after Sowers, 1979)				
PLASTICITY INDEX Ip	**CLASSIFI CATION**	**DRY STRENGTH**	**VISUAL - MANUAL TIFICATION OF DRY SAMPLE**	**Classification of the tested sample**
0-3	Non plastic	Very Low	Falls apart easily	
3-15	Slightly plastic	Slight	Easily crushed with fingers	11.09
15-30	Medium plastic	Medium	Difficult to crush with fingers	
>30	Highly Plastic	High	Impossible to crush with finger	

The soil falls under the slightly plastic category, as its Plasticity Index (PI) is 11.09, placing it within the 3–15 range (BIS, 1970). This indicates the presence of some clay content, though the soil is not highly cohesive or expansive (Das, 2013). The dry strength of the soil is slight, meaning it has low resistance to crushing when dry. As a result, it may be prone to crumbling under mechanical stress. The soil sample is easily crushed with fingers, further confirming its slightly plastic nature. While it exhibits some plasticity, it lacks strong cohesion in a dry state. The slight plasticity of the soil suggests moderate shrink-swell potential, leading to minor volume changes with moisture fluctuations (Murthy, 2017). To enhance stability, proper drainage and compaction techniques are recommended before construction. Due to its low plasticity, the soil does not retain excessive moisture, making it suitable for road subgrades and embankments; however, stabilization may be necessary for load-bearing applications to improve strength and reduce settlement risks (Craig, 2004). Additionally, the low dry strength indicates high susceptibility to erosion from wind and water forces, requiring protective measures such as vegetation cover or geotextiles in construction projects to prevent soil loss (Table No. 2).

Conclusion

The analysis of the soil properties indicates that it falls under the inorganic clay of medium plasticity category, with a Plasticity Index (PI) of 11.09%. This classification suggests moderate cohesion and compressibility, making the soil suitable for moderate-load-bearing applications such as low-rise buildings, pavements, and industrial floors.

The Maximum Dry Density (MDD) of 1.80 g/cm³ and Optimum Moisture Content (OMC) of 14% indicate that the soil achieves maximum compaction at moderate water content, enhancing its stability. However, the specific gravity of 1.60 is relatively low, possibly indicating the presence of organic matter or lightweight particles.

The direct shear test results reveal a cohesion value of 0.130 kg/cm² and a friction angle (Φ) of 26.53°, suggesting moderate shear resistance. While the soil can support structural loads, it may experience moderate settlement under heavy loads, requiring proper foundation design considerations.

From a geotechnical perspective, the slightly plastic nature of the soil implies moderate shrink-swell potential, making it prone to minor volume changes with moisture fluctuations. Its low dry strength means it is easily crushed and may be susceptible to erosion, requiring protective measures such as drainage control, vegetation cover, or geotextiles.

Overall, while the soil is suitable for general construction applications, stabilization methods may be necessary for high-load structures or areas with high moisture variation. Proper compaction, drainage management, and erosion control strategies should be implemented to enhance its performance and long-term stability.

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