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Investigation of Naseeb Singh Slide at Dharamthal Village along NH-44, Jammu and Kashmir (India): A Case Study

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Abstract

The Himalayan region faces a significant threat from landslides and slope failures, with the Jammu-Srinagar National Highway (NH-44) being particularly vulnerable to numerous active landslides during the rainy season. Among these, the Naseeb Singh landslide, situated at a distance of 80 km from Jammu, stands out as one of the most problematic and actively moving landslide along the Udhampur and Chenani stretch of the highway. This troublesome slide, covering an area of approximately 12,000m², is classified as an earth slide and has caused damage to building, agricultural land and the road. This slide exhibits multiple episodes of movement. The objective of this paper is to conduct a thorough assessment and gain a comprehensive understanding of the factors responsible for triggering this landslide. To achieve this, we will employ a "cause and effect" model as the fundamental approach for our investigation. The geotechnical analysis strongly indicates that the initiation of the slide is influenced by a combination of human activities and natural factors, with heavy rainfall being a significant in this regard.

Key Words: *Landslide, National Highway (NH-44), Jammu, Earth Slide, Cause and Effect*

INTRODUCTION:

Landslides/slope failures are a common occurrence on Earth, irrespective of altitude, lithology, or season. However, the rapid increase in anthropogenic activities for developmental purposes has significantly impacted hill slope stability in the entire Himalayan region. As a result, the study of landslides has become a focal point for major scientific research and practices. Various studies on Himalayan geo-environmental degradation, including those by Bhandari (1987), Rao (1996), Sah et al. (2003), Mazari et al. (2003), Sah & Bartarya (2004), Singh & Bhat (2010; 2011), Singh et al. (2014) have revealed the severe nature and consequences of slope failures in the region. The Jammu-Srinagar National Highway (NH-44), the vital surface link connecting the valley of Kashmir with the rest of India, passes through the fragile Himalayan terrain in Jammu Division of Jammu and Kashmir. Landslides along this highway have been a recurring problem since the first one was recorded in 1956, causing disruptions to traffic movement and posing risks to lives, property and passengers in the area. While considerable knowledge has been gained in understanding landslide hazards, in this part of Himalaya through various works carried out by different workers (Andrabi and Haq, 2002; Singh, 2006, Singh and Bhat, 2010, 2011; Singh et al., 2014; 2018; Sangra et al., 2017; Hussain et al., 2018; 2019), there are still significant gaps in comprehending the mechanisms behind landslides in this region. In this study, the focus is to determine the possible causes of the landslide and suggest instantaneous measures to stabilize it. Notably, previous landslide studies worldwide have mostly concentrated on catastrophic landslides characterized by extremely rapid kinematic mechanisms and mobility. Various hypotheses and correlations have been proposed to explain these events, such as those by Heim (1932), Shreve (1968), Hsu (1975), and Sassa (1989). However, none of these have been widely recognized as universal explanations for landslides, likely due to the significant variation in landslide characteristics and our limited understanding of their mechanisms. The present study aimed to establish a relationship between various parameters through geotechnical investigation to gain a deeper understanding of the triggering mechanisms behind the failure.

STUDY AREA:

The present study covers an area having latitude – 33º00′39″N and longitude – 75º13′36″E situated within the region spanning from Udhampur - Chenani (Fig.1.1) and falls within the Outer Himalayan tectonic zone. In this zone, the Murree strata overlay the buried peneplained surfaces of the northern fringe of the Indian shield, as documented by Parkash et al. (1980). The area is characterized by an immature and rugged topography with moderate to high forested slopes and noteworthy differences in elevation. Mountain ridges are deeply incised, forming steep and narrow gorges. The climate in the study area ranges from hot and humid tropical to subtropical severe cold. It experiences substantial rainfall during both winter and monsoon seasons, with an average annual rainfall of 1040 mm recorded at Udhampur. The minimum and maximum rainfall intensity recorded in the region falls within the range of 1.61 and 2.49 mm/hr, respectively.

GEOLOGY AND STRUCTURE:

The study area contains rocks from the Murree Group, which belong to the Tertiary age and is a part of the Himalayan Foreland Basin (Fig. 1.1). The exposed rocks in the area are primarily from the Upper Murree, consisting of consolidated red and grayish green sandstones, along with occasional unconsolidated reddish mudstones that sometimes exhibit a splintery nature. The region is characterized by significant structural features; including the Jhajjar-Mansar thrust cored anticline, Main Boundary Thrust (MBT), Udhampur syncline, Mundan Thrust, Tanhal Thrust, Kishanpur thrust, Palkhai Syncline, Kud-Mantalai Syncline, and Murree Thrust. Among these, the most prominent one in the study area is the Main Boundary Thrust (MBT), which serves as the demarcation between the Siwalik Group and the Murree Group in the region.

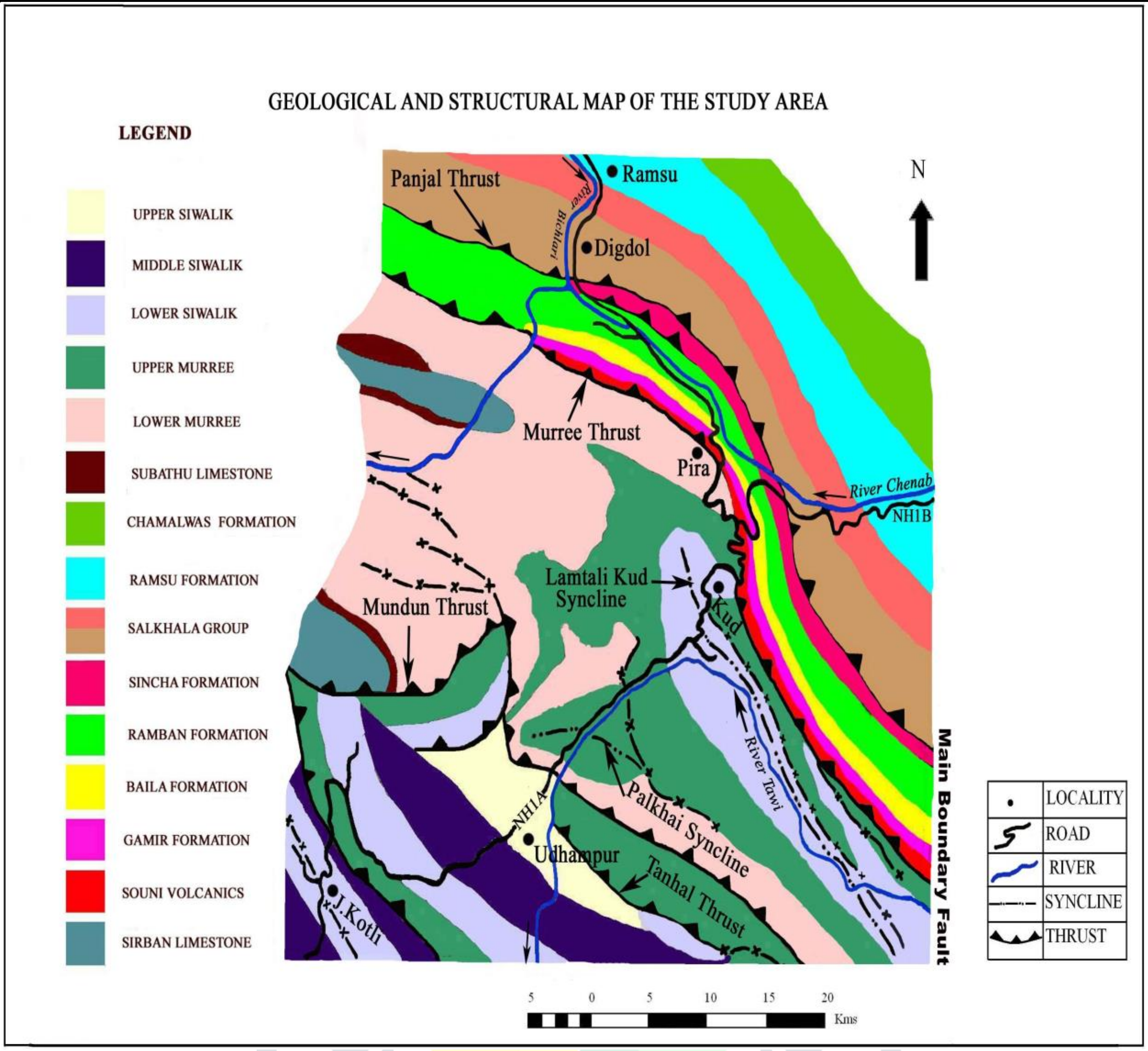

Fig. 1.1: Geological map of the study area (Singh, 2006).

FIELD OBSERVATIONS:

The rocks exposed in this area consist of highly weathered sandstone with brownish and maroon colored mudstone. The slide situated on the left side of the national highway (NH-44), while heading towards Srinagar from Jammu. The sliding area primarily comprises terraced deposits and agricultural land and covers an area of approximately 12,000 m², and based on its areal extent, it is classified as a medium-sized landslide (Van Schalkwyk and Thomas, 1991). Moreover, considering the type of movement and the geological material involved, it falls under the category of an earth slide (Varnes, 1978). The slope angle within the sliding area varies from 46 to 69 degrees. As a result of the recent sliding, extensive wide-open transverse and longitudinal cracks have been observed along the slope, with depths ranging from 75cm to 1.5m and widths from 10cm to 76cm (Fig. 1.2a-d). These cracks were traced uphill up to the crown of the slide and extend into the residential complex of Naseeb Singh as well. Additionally, there has been lateral and vertical displacement of approximately 35cm and 45cm, respectively, observed around the water tank located at the crown of the slide. The ongoing excavation work for road widening at the base of the slope coincided with subsequent rainfall. During the investigation, it was noted that water was still flowing in the sliding area at a rate of 200ml/second, originated from the stream running adjacent to the slide. This excessive water presence oversaturated the material and the space created by the ongoing excavation at the base facilitated outward movement, leading to the failure of the slide. The landslide caused significant damage to one of the drainage channels constructed to divert water (Fig.1.2e). Moreover, another drainage channel, intended to redirect water away from the slide, has been left incomplete in the middle of the slide (Fig.1.2f) has further aggravated the situation.

a) b) c) d)

e) f)

Fig. 1.2: Field photographs (a-d) showing wide open and deep cracks at the different portion of the slide; e) displaced drainage channels and f) incomplete drainage left in the sliding area.

LABORATORY INVESTIGATIONS:

To establish a suitable correlation among various soil parameters, four soil samples (NS1-NS4) were collected at a depth of around 20cm from the top from the sliding area and subjected to various tests(Table 1.1-1.3). The grain size analysis indicated that the dominant fraction in these soils is sand, ranging from 31.25% to 39.52%, followed by silt, ranging from 24.60% to 30.30%. This suggests that the soils belong to the silty sand type (Table 1.1). The clay fraction ranges from 15.60% to 23.58%. The most crucial soil characteristic is its texture and structure, which significantly influence water absorption and retention capacity. Sample NS3 exhibited higher clay content (23.20%) and a lower absorption ratio (18.52) compared to sample NS4, which had higher clay content (23.58%) and higher absorption ratio (21.21). The soil texture is determined by the proportion of soil particles, whereas soil structure affects water movement through the soil. The mechanical analysis of the samples revealed that the higher sand fraction resulted in reduced cohesion and consequently decreased shear strength, ultimately leading to an increased infiltration rate. Sand contains relatively large pores that facilitate higher rates of infiltration, and the sand grains tend to remain separated without significant cohesiveness. The larger pores in the sand at the investigation site allow the soil to quickly absorb significant amounts of rainwater, leading to enhanced infiltration rates and an increased potential for sliding, particularly in lithologies sensitive to water.

The specific gravity values (Table 1.2) of the soil samples in the study area shows a considerable range, varying from 2.46 to 2.71. This significant variability in specific gravity within the same location indicates differences in soil composition, which can lead to varying degrees of soil deterioration. Higher specific gravity is associated with lesser deterioration, while lower specific gravity indicates more susceptibility to deterioration. Consequently, soils with such diverse specific gravity values are expected to behave differently when subjected to the same triggering forces, leading to complex problems. The specific gravity values of the soil mixture in the study area suggest that the soil is sensitive to weathering. The void ratio and porosity values (Table 1.2) in the study area range from 0.439 to 0.732 and 0.305 to 0.423, respectively. The bulk and dry density values (Table 1.2) for the analyzed samples range from 1.46 to 1.53 and 1.56 to 1.68, respectively. The permeability values of the analyzed samples range from 4×10^{-3} to 7×10^{-3}.

The medium values of void ratio, porosity, and permeability observed in these samples can contribute to slope failures, depending on the amount and timing of precipitation concentration. Due to their medium permeability, water percolates downwards, even reaching the bedrock. This downward movement of water increases pore pressure and leads to slope instability (Anbalagan et al., 1996; Prakash et al., 2002; Singh, 2006, Singh and Bhat, 2010, 2011; Singh et al., 2014; 2018; Sangra et al., 2017; Hussain et al., 2018). It is essential to take these factors into account when assessing soil stability and potential risks, as the excess water content and reduced shear strength can compromise the overall stability of the soil mass. Understanding the soil's consistency is crucial for evaluating its behavior under various conditions, such as its ability to support structures, susceptibility to deformation, and response to changes in moisture content.

The liquid limit represents the moisture content at which the soil transitions from a plastic state to a liquid state, while the plastic limit indicates the moisture content at which the soil ceases to exhibit plastic behavior. The plasticity index (Table 1.3) denotes the range of moisture content at which the soil remains in a plastic state. In this study, the liquid limit values range from 23.5 to 25.5, and the plastic limit values range from 14.3 to 17.2. The moderate values of the liquid and plastic limits suggest that the soil requires a relatively higher amount of water content to shift from a plastic state to a liquid state. This indicates that the soil possesses some degree of moisture resilience and may not become highly fluid with small increases in water content. However, it also suggests that the soil's shear strength may be reduced when subjected to wetting and drying cycles, potentially contributing to increased instability and susceptibility to landslides when combined with other factors. Similarly, the plasticity index value, ranging from 7.8 to 9.3, reflects the range of moisture content within which the soil remains in a moderately plastic state.

Table 1.1: Grain size analysis and water absorption values

S. No	Grain Size				Abs. Ratio	Soil Type
	Gravel	Sand	Silt	Clay		
NS_1	16.50	37.60	30.30	15.60	19.90	Silty Sand
NS_2	15.72	39.52	25.20	19.56	19.46	Silty Sand
NS_3	18.40	31.25	27.20	23.15	18.52	Silty Sand
NS_4	15.87	35.37	25.18	23.58	21.21	Silty Sand

Table 1.2: Specific gravity, void ratio, porosity and density values

S. No	Sp. Gravity (G)	Void Ratio (e)	Porosity (η)	Bulk Density (gm/cc) (p)	Dry Density (gm/cc) (pd)
NS_1	2.71	0.732	0.423	1.47	1.67
NS_2	2.69	0.702	0.413	1.49	1.56
NS_3	2.46	0.439	0.305	1.46	1.57
NS_4	2.52	0.560	0.359	1.53	1.68

Table 1.3: Consistency limits values

S. No	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Flow Index (FI)	Toughness Index (T I)
NS_1	23.7	14.4	9.3	12.8	0.63
NS_2	25.5	16.4	9.1	15.3	0.62
NS_3	23.5	14.3	9.2	13.9	0.66
NS_4	25.0	17.2	7.8	10.6	0.73

DISCUSSION:

The mechanical analysis of the soils highlights the presence of a dominant sand fraction, which leads to reduced cohesion and subsequently lowers the shearing strength. The larger pore size in the sand grains, along with higher effective porosity, creates conditions favorable for rapid infiltration of large amounts of rainwater over a short period. This enhances the water percolation rate in the soil, and the space created by the road widening activities at the base further facilitates outward movement by increasing the driving force in the sediments, while the soil loses its resisting force, ultimately resulting in failure. The inconsistency among the Atterberg's limit, low to moderate absorption values, and medium permeability also contributes to the potential for failure. These factors collectively create a complex and unstable environment, increasing the susceptibility of the soil to landslides and other forms of slope failure.

RCOMMENDATION:

1. The space created by road widening activities at the base of Nasseb Singh slide should be carefully managed to avoid exacerbating outward movement.

2. It is important to limit water ingress into the slope by controlling surface runoff and properly directing water away from the slope.

3. The detailed geotechnical assessment of the site is required for appropriate mitigation measures.

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