Incidences of Slope Failures along NH-1A, Jammu & Kashmir

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Abstract

The approach road to the intrinsic Kashmir valley transects through the awesome crests of the Himalaya. Frequent incidences of landslide activities along the National Highway-1A, is a matter of constant concern to the inhabitants, tourists and the planners. The strong precipitation during the monsoon causes failure of rock mass, which ultimately leads to landslides along this road. Some of the slides are also developed due to the breaking away of highly jointed and sheared rocks, which fail during the course of road construction/ widening, or due to water action. Suitable slope stabilization measures are needed to be planned and initiated in the active slide areas, prioritizing the areas of strategic and societal concerns.

Introduction

The land utilization is one of the major components of urbanization or developmental activities. The fragile mountainous terrain of Himalaya could not escape such onslaught of man made endeavors. The natural processes of landforms are also result of earth's dynamic system. These two components put together provide a very complex interplay of various factors responsible for the generation of landslide risk of varying degree in mountainous terrain. High relative relief, steep slopes, concentrated rainfall with high rates of surface flow together with the ongoing tectonism make the region highly prone to slope instability.

The National Highway-1A is an approach road from the Gangetic plains in Punjab to the picturesque valley of Kashmir through Jammu, Udhampur, Ramban and the state capital Srinagar. The road transecting through the strategic and fragile Himalayan terrain is frequently affected by slope failures, snow avalanche etc. It is the only major road link to Kashmir valley and acts as a lifeline for civilian and strategic purposes. The regular recurrences of the landslides at several places along this national highway especially during winter and monsoon months remain a matter of grave concern. Therefore record of landslide incidences remains an essential step in understanding the nature of slope and proper management methods to mitigate the natural disaster by designing effective repairs.

The area is represented by moderate to high mountains and deep valleys suggesting a young mountain system. The ridges with a general trend of NS to NW-SE reflect a strong control of regional strike and tectonic features. Most of the inter-montane valleys are 'V' shaped with deeply dissected profiles. River terraces also form a prominent part of the geomorphological landscape. At the early stage, the rivers of the area follow transverse inter-montane valleys trending roughly at right angles to the trend of the Himalaya, subsequently they flows conforming the regional trend of the Himalaya.

Being a major strategic and important route, the NH-1A boasts of some prominent locations of strategic and civilian importance. These townships have a greater fraction of built-up areas and are restricted mainly to river terraces. Semi-barren areas are a common feature all along the route, made

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up mainly of slope wash and/or terrace material and rocky mass.

Geological Set-up

The area forms part of the Higher Himalayan Palaeogene (Late Palaeocene to Early Miocene) and Pleistocene sequence of rocks, which are capped by Quaternary sediments. It forms a thick pile of argillaceous, arenaceous and calcareous facies. These together form an Early Palaeogene Subathu Formation and a Late Palaeogene Murree Group. A generalized stratigraphic succession of the area is given as under (after GSI, 2005).

The structural discontinuities along this road section are mainly Panjal Thrust, Murree Thrust and Main Boundary Thrust. Autochthonous zone is the southern most structural unit of main Himalayan belt, which is bounded by Murree Thrust in the south and Panjal Thrust in the north (Jangpangi *et al.*, 1986) and forms the northern most part of this road section. The Panjal Thrust is a high angle reverse fault dipping towards north separating the rocks of the Nappe zone from the Autochthonous folded belt. The Murree thrust is also a reverse fault dipping at varying angles towards north to vertical in certain areas and is running almost parallel to the Panjal thrust.

In context of landslides, unconsolidated Quaternary deposits, comprising river borne material, fan alluvium, slope wash and scree are widespread along the river valleys and on valley slopes are of utmost importance. These are composed of sub-rounded to rounded pebble and boulders of quartzite, gneiss, dolomites and volcanic rocks in silt and sandy matrix with silt and sand lenses at places. In this area quaternary sediments are confined to parts of Chenab basin and have been classified

		Sub-group/ Formation	Age
Quaternary		Recent deposits	Holocene
		Chenab Formation	
		Vaishno Devi Formation	
Siwalik Group		Upper Siwalik subgroup	Early Miocene to Pleistocene
		Middle Siwalik subgroup	
		Lower Siwalik subgroup	
---------- Main Boundary Fault ----------			
Murree		Upper Murree Formation	Mid Eocene to Oligocene
		Lower Murree Formation	
---------- Murree Thrust ----------			
Autochthonous Zone	**Upper**	Poonch- Mandi Formation	Upper Carboniferous to Eocene
		Zewan Formation	
		Panjal volcanics	
		Agglomerate slate	
	---------	**--------- Unconformity ----------**	----------
	Lower	Sincha Formation	Late Proterozoic
		Ramban Formation	
		Baila Formation	
		Gamir Formation	
		Bhadrawah Formation	
		Tanawal Formation	
---------- Panjal Thrust ----------			
		Salkhala Group	Mid Proterozoic
		Sirban Limestone	Mid Proterozoic

in to Vaishno Devi and Chenab formations (after GSI, 2005). Vaishno Devi Formation is an assorted assemblage of angular to subangular fragments of gravel to cobble size with occasional boulders of limestone/ dolomite. This formation has developed at the foot hill of the Trikuta hill and covers large tracts of Katra - Jhajjar Kotli surface. A crude stratification has been observed suggesting different cycles of sedimentation within the formation. Chenab Formation is present in the form of terraces in the middle and upper reaches of the Chenab river. This formation comprise poorly sorted assemblages of rounded to well rounded boulders/cobbles/ pebbles/gravel size clasts of volcanics (Panjal trap), purple siltstone/sandstone (Murree Formation), grayish sandstone (Middle Siwalik), limestone/dolomite (Sirban Limestone), quartzite and gneisses in different proportions. The formation is well distributed on either bank of Chenab river, all along the course. The recent deposits are also associated with the active flood plain of the major tributaries. These deposits are restricted to the present day channel courses and adjoining land areas.

Landslide Incidences

Systematic monitoring of slope failures greatly aid in understanding the geological and other factors responsible for the landslide occurrences and contribute significantly to hazard mitigation programme. The Himalayan rocks are not only structurally deformed, but are also subjected to natural processes of denudation, which aggravate mass wasting phenomenon. Important natural factors are :

(i) steep slope with high relative relief
(ii) groundwater flow accentuating slips of land
(iii) cloud burst and intense rain and/or snow fall events
(iv) toe undercutting by torrents and floods

Furthermore, anthropogenic activities can also substantially aggravate its impact and scale in the form of loss of forest cover, and extension of agriculture into steep slopes. Road building and road widening without regard to geological factors have added an altogether new and important dimension to the problem of landslide.

Along the road section under study, a total of 49 landslides, which are mainly debris slides except few, debris cum rockslides, were marked. A brief description of the terrain conditions and the slope instability phenomenon, along certain vital sections is given, as under -

(i) Chanderkot-Ramban-Seri section

In this section, the road is cut through the interbedded sequence of rocks of Auto-chthonous folded belt. Along the total length and in close vicinity of this section, twenty major slides have been recoded. The section contains the major Kehia maur slide, Seri slide zone and Ramban slide zone. The Ramban slide zone (Photo-1) is debris slide on which regular recurrences of slide are reported. It forms the earlier left bank alignment of the NH-1A, which is now closed for regular traffic. Another alignment of NH-1A was made and opened for regular traffic on the right bank of the Chenab river, which is also affected by the debris slide. The widely dispersed manifestation of the fragility of highly folded and sheared metamorphic rocks is the major contributing factor. These rocks are susceptible to nala erosion by the surface water. Freezing and thawing action of snow and melt water resulted in gully erosion of the debris mass, rendering the slope unstable. Furthermore, process of road building/ widening results into the recession of the slides vertically as well as laterally. The Seri slide is a debris cum rock slide in which, the fragile rock mass of mudstone is converting into the debris, which is susceptible to failure. Another slide along

Mitra *nala* is also one of the major landslides affecting the national highway. It is also a debris slide induced by toe undercutting of the *nala*. For containing these slides, back dressing/easing of overburden slope profile near the head, benching, and boulder pitched wall with wire crate at critical spots besides providing geo-jute cover all along the slide surfaces could be suitable for their mitigation.

(ii) Pira - Chanderkot section

Here also the road is passing through the interbedded sequence of Autochthonous folded belt. In the close vicinity and along the total length of this section, nine major slides have been recoded. This section contains the major Nashiri slide zone (Photo-2), which has affected more than one km of the road section as well as nearby villages of Khandel and Nal, which are affected by its southern extension. It is a massive debris slide caused by nala erosion. Steep gradient of nala with huge discharge during monsoon accelerates toe erosion, resulting in to retrogressive slide of debris material resting on the steep slopes of about 50°. The fresh and barren nature of the detached slide mass and scarp with freshly fallen trees indicate active nature of slide and exposed rocks of fragile nature at crown with steep slopes provide enough space for slide to grow. For containing the slide, back dressing/easing of overburden slope profile near the head, benching, and boulder pitched wall with wire crate at critical spots besides providing geo-jute cover all along the slide surface may be of use. Diversion of Nashiri *nala* along the road can prevent the road by further recurrences of landslide, as toe cutting in the lower reach could be avoided.

Near Dalwas village, a major mudflow was recorded. The retaining wall was disturbed probably due to unsuitable design and improperly managed or chocked weep holes. During monsoon this area will be a major blockage on the national highway as well as threat to the villages located above the crown of this slide, which needs suitable corrective measures and properly designed retaining structure for its mitigation.

(iii) Patnitop-Kud-Chinenei-Dharamthal section

Along this section eleven major slides have been recoded in which the major slide is at sharp hairpin bend near the Patnitop pass. This is a massive rock cum debris slide (Photo-3) caused by competency contrast between the interbedded sequence of sandstone mudstone and siltstone of Murree Formation. During rain/snow fall, surface runoff and seepage of water through the mud/ siltstone make the rock mass more fragile and susceptible to erosion, which ultimately leads to failure of slopes involving bigger sandstone boulders. Another major debris slide affecting the road is at 92 km stone in which younger riverbed deposits are failing due to gully erosion during monsoon. Slope flattening and benching, boulder pitched wall with wire crate at the road level can contain these slides and prevent the road by further recurrences.

(iv) Dharamthal-Udhampur-Jhajjar Kotli section

Along this section seven major slides have been recorded. The Dharamthal slide and slide between Nagnoo and Maund bridges are the major zones of debris failure while the one which is at 77 km stone along the road is a typical example of planar failure (Photo-4). Retaining structure at road level and back dressing/ easing of overburden is the suitable measure to contain this type of slide. The Main Boundary Fault also passes through this section separating Murree Group of rocks from Siwaliks. Here another debris slide is active along the left bank of Tawi river in which the river borne terrace material has been dislodged, affecting the field and village population on the lower terrace (T-1).

(v) Katra-Painthal-Tikri section

Along the Tikri-Katra road section, Sirban dolomites and Quaternary sediments (overburden mass) are exposed. There are only two problematic landslides (Photo-5) recorded along the road. They are debris slide in an assorted assemblage of angular to sub angular fragments of gravel to cobble size with occasional boulders of limestone/ dolomite of sub-recent Quaternary sediments of Vaishno Devi Formation. These slides are initiated due to toe erosion by the river and further aggravated by surface runoff and water seepage into the fragile deposits. Here provisions of toe support by providing retaining structure and scaling to remove rock overhangs are the suitable measures to contain these slides.

Conclusions and Recommendations

National Highway-1A being the lifeline of the Jammu and Kashmir state, suitable arrangements for containing and controlling slides must be made in advance to ensure uninterrupted supply line and safety of life and property. Water is the major culprit in land instability hence surface water must be prevented from infiltrating the potential slide masses. Land hazard zoning characteristics and catagorisation of area in to various zones of LSZ map can greatly help the planners in identifying the vulnarable areas so that they are forewarned and can take suitable hazard management measures. The remedial measures suggested are based on the preliminary investigation, however, in the event of pressing need of developmental programmes and schemes it would be advisable to carry out detailed geotechnical site or case specific investigations of the slides.

Landslide prevention is difficult but the damages can be reduced by taking effective control and preparedness measures for disaster management. Information, education and communication (IEC) components can be of great help in reducing the loss due to a disaster.

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Photo-1. Ramban slide

Photo-2. Nashri slide

Photo-3. Rock cum debris slide near Patnitop.

Photo- 4. A planar failure at 77 km stone along the road

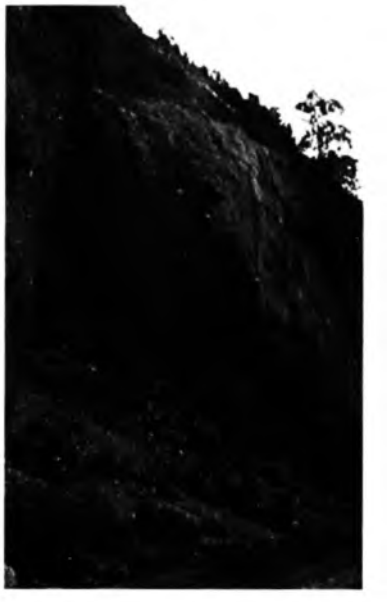

Photo-5. Debris slide near Painthal.