

Landslides Management in Rural Roads of Pauri District (Uttarakhand): Challenges & Opportunities

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Abstract

Landslides are one of major geohazards in mountainous regions, often leading to severe damage to life & property, state of Uttarakhand is not exception. Causes associated are both, natural as well as anthropogenic. Under normal climatic conditions, a majority of the valley slopes are in the state of geomorphic equilibrium. Rain normally triggers the landslide by raising the water table and water pressure, which ultimately leads to slope failure, often get accelerated due to ongoing road constructions activities. An effective management of aforementioned geohazaard along rural roads in Pauri district or elsewhere requires understanding of spatial & temporal aspects related with the hazard scenario across the road networks. Assessment , Quantification of landslides, Mapping ,Hazard Zonation , Development of adequate institutional capacities along road networks are main challenges due to in-adequately documented inventories & mapping about the spatial probability of hazard (susceptibility), temporal probability, and magnitude-frequency analysis

The project area consist of sub-projects i.e. total number of 18 roads for a total length of 286.20 Km. The proposed improvement roads falls in Pauri Garhwal, a district of Uttaranchal state. It encompasses an area of 5440 sq. km and situated between 29° 45' to 30°15' Latitude and 78° 24' to 79° 23' E Longitude and at 1650 meters above the Mean Sea Level...The District is administratively divided into six tehsils, viz., Pauri, Lansdown,

Kotdwar, Thalissain, Dhumakot & Srinagar, and fifteen developmental blocks, of which eleven blocks are coming under the project area viz. Pauri, Pabo, Thalissain, Bironkhal, Dwarikhal, Dugadda, Jaihrickhal, Ekeshwer, Rikhnikhil, Nainidanda & Khirsu. Highly significant numbers of landslides, approximately 25 in each ten kilometers of each road have been observed. Treatments of all such slides depends upon the severity which is determined on the basis of degree of slopes. Majority of these slides belong to severe to moderate categories. Slope geometry correction, providing protection to the toe of slope by retaining structures, management of the surface and sub-surface water including the development of pore pressures, nailing, bolting, anchoring, micro piling, application of geo-grids and geo-textiles and afforestation, constitute powerful elements of most geotechnical packages commonly used for improving the stability of problematic slopes and landslide sites in India

Landslides investigation & management activities were carried out for seventeen roads of four contract packages, as outlined in the table 1, given below:

Table 1: Roads of Sub-contract Packages in Pauri districts

S No.	Contract Package	Roads	Current Length	Width of proposed road + shoulders+ Drain+ parapets	
				Carriageway	Formation
1.	16.	Sungarkhal-Jwalapadevi Motor Road	30.100 km	3.75m + 0.5 m + 0.5 m +0.5 m + 0.5 m= 5.75 m	
		Santodhar-Pabao Motor Road	30.770 km		
2.	17.	Banekh Thapla	11.20 km	3.75m + 0.5 m + 0.5 m +0.5 m + 0.5 m= 5.75 m	

		Kanmothlia Jandadevi	16.00 km	
		Satpuli- Dudharkhal	25.00 km	
		Semkhal Sauli Bend	8.00 km	
		Dudharkhal Tadkeshwar	6.00 km	
3	19.	Chailusain- Devikhet	10 km	3.75m + 0.5 m + 0.5 m +0.5 m + 0.5 m= 5.75 m
		Hanumanti- Fatehpur	6.00 km	
		Matyali- Dwarikhal	17.20 km	
		Kandakhal- Chailusain	15.00 km	
4.	20.	Dhumakot- Nainidanda	13.50 km	3.75m + 0.5 m + 0.5 m +0.5 m + 0.5 m= 5.75 m
		Soparkhal- Lalitpur	13.50 km	
		Khaludanda- Apolasera	13.00	
		Rikhanikhal- Thailisain via Jaspurkhal	5.50 km	
		Rikhanikhal- Thailisain via Bhagtalia	7.00 km	
		Rikhanikhal- Thailisain via Panas village	7.00 km	

Key observations regarding causes, severity & mitigations measures implemented for the management of landslides in rural roads as outlined in table 1 are as follows:

- Most of the slides observed belong to very severe to severe category.
- Majority of Landslides are Debris fall, Mudslides and Rock falls
- Season of frequent occurrence of these landslides in rainy season (Monsoon)
- Threats of damage to life & property exists in majority of slides
- Lithologies of slides are not very different; vary from weathered sedimentary & metamorphic rocks getting converted to clay due to years & years ex-situ & in-situ weathering.
- Slope instability becomes prominent due to delayed construction of civil mitigation measures after hill cuttings being done for road constructions.
- Road constructions related activities combination with natural causes i.e. soil saturation at highly weathered lithologies steep slopes resulting in increased pore water pressures which get more severe due to the lack of appropriate drainage network, sudden cloud bursts induced floods and continuous & unchecked deforestation are among major causes of frequent landslide activity.
- A mix of civil engineering & vegetative measures have been suggested in order to prevent & control risk to damages to life & property. Major mitigation measures suggested are:
 - *Removal of unstable materials from slopes*
 - *Shifting of road alignments*
 - *Improvement of surface water drainage to avoid & prevent excess pore water pressure*
 - *Benching of slopes by dividing long slopes into smaller segments*
 - *Breast walls\Check walls*
 - *Crete wire Structures*
 - *Retaining walls*

- *Protection walls*
- *Geotextile with nails*
- *Plantation of local species of plants, grasses & shrubs.*

Dimension of above mentioned mitigation measures varies from one slides to another depending upon the aerial extent, causes, severity. Similar is the case with cost of implementing suggested mitigation measure. Photographs 1 & 2 provide glimpses of two mitigation measures implemented widely in Contract Package-17 in rural roads of Pauri district. More photographic details about road & location specific measures will be provided in the detailed paper



Photograph 1: Mitigation Measure – Breast wall on the road of Contract Package-17



Photograph 2 : Mitigation Measure – Gabion with Wirecrete on the road of Contract Package-17

The present paper intends to briefly describe, analyze & review the causes of landslides occurrence and mitigation measures implemented so far in rural roads of Pauri district, while identifying challenges & opportunities associated with required institutional capacities in assessing slope failure possibilities, hazard zonation & mapping along with innovative approaches to be followed for the management of landslides in the same region.