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सेवा में,

निदेशक,
यू0एल0एम0एम0सी0,
उत्तराखण्ड शासन, देहरादून।

विषयः आपदा न्यूनीकरण मद के अंतर्गत वित्तीय स्वीकृति हेतु विभिन्न रेखीय विभागों से प्राप्त प्रस्तावों का तकनीकी परीक्षण किये जाने के सम्बन्ध में।

संदर्भः (क) आपदा प्रबन्धन, अनुभाग–1का पत्रांक–757/XVIII-B-1/2023-15(04)2022 दिनांक 30.05.2023।
(ख)आपदा प्रबन्धन, अनुभाग–1का पत्रांक–304/XVIII-B-1/2024-15(25)2021 दिनांक 21.03.2024 (E-40010)।

महोदय,

अवगत कराना है कि उपरोक्त संदर्भित पत्र (ख) के माध्यम से दिये गये निर्देशों के क्रम में इस कार्यालय के स्तर पर संदर्भित पत्र (क) के माध्यम से गठित `समिति` द्वारा लोक निर्माण विभाग एवं PMGSY, कर्णप्रयाग के कुल 02 प्रस्तावों का परीक्षण भारत सरकार द्वारा जारी एस.डी.एम.एफ. सम्बन्धी दिशा–निर्देशों (गृह मंत्रालय, आपदा प्रबन्धन खण्ड, भारत सरकार के पत्रांक–33-02/2020-NDM-I, dated 14.01.2022) के आलोक में पूर्ण कर लिया गया है।

अतः लोक निर्माण विभाग एवं PMGSY, कर्णप्रयाग द्वारा प्रेषित विषयांकित 02 प्रस्तावों का परीक्षण एवं स्थलीय निरीक्षण की आख्या/सुझाव (मूल में) संलग्न कर आपके अवलोकनार्थ प्रस्तुत हैं।

संलग्नक–उपरोक्तानुसार।

भवदीय,

डॉ0 रघुवीर सिहं नेगी
जियोलॉजिस्ट,
यू0एल0एम0एम0सी0।

विशाल रस्तोगी, सदस्य
बायो इंजीनियरिंग विशे.,
यू0एल0एम0एम0सी0।

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Field Visit Report

Site: Dhurma- Kundi Road (KM-2), Nandanagar (Ghat), District - Chamoli

Dated: 27 April 2024

1. Introduction

Dhurma- Kundi (Village Road) is situated under Tehsil Ghaat, District Chamoli. The total length of said road is 4 KM and constructed by Public Works Department in year 2015-16. Due to excessive rain a portion of approx. 60 m of said road is washed away said road and about 100 m span fallen under a sliding zone. To restore the road connectivity, PWD has evolved following project proposal for road re-alignment; worth Rs 60.07 Lakh and submitted under the State Disaster Mitigation Fund (SDMF) scheme-

"राज्य आपदा न्यूनीकरण निधि (एस0डी0एम0एफ0) वर्ष 2023–24 के अन्तर्गत धुर्मा कुण्डी मोटर मार्ग के कि0मी0 02 में भूस्खलन से बचाव एवं सुरक्षात्मक कार्य।"

2. Objective/Scope of Visit

In compliance of orders received from Director General, ULMMC, a team of following officials visited the site on April 27, 2024, to examine the current status of site and to identify the scope of mitigation measures including Bio-engineering -

i. Shri Vishal Rastogi, Bio-Engineering Specialist, ULMMC, Dehradun.
ii. Dr Raghuveer Negi, Geologist, ULMMC, Dehradun.
iii. Shri Sachin Kumar, Executive Engineer, PMGSY, Karanprayag.
iv. Shri S K Rai, Geologist, PWD, Pauri.
v. Dr Tushar Sharma, Geologist, PWD Almora.
vi. Shri P L Dangwal, Junior Engineer, PWD Karanprayag.

The team has conducted a site visit on 27 April 2024; to assess the site conditions on various parameters in light of mitigation measures including Bio-engineering.

3. About Nanda Nagar (Ghaat)

Ghat is a Tehsil, under District Chamoli and connected to Nandprayag on Rishikesh-Joshimath National Highway. On local public demand the name of concern town is changed to Nanda Nagar from Ghaat and accordingly name of Development block also changed to Nanda Nagar. It is approximately 280 KM away from State capital Dehradun.

Ghat Tehsil is an agricultural area and situated on the bank of river Nandakini in middle Himalayas. The area is often plagued by cloudbursts and landslides. Ghaat Block comprises total 97 villages with a total population of 37,408 and 7683 house holds.The SC and ST population is 22% and 1.2% respectively and has an average literacy rate of 76.6%.

4. About the Site

Total length of Dhurma - Kundi motor road is 4 KM + 01 Bridge (21 m) and estimated cost is about Rs 122.10 Lakh. Stage -I &II of Dhurma - Kundi motor road construction works were completed in the year 2015-16. The road is situated in Nanda Nagar (Ghat) Development Block of District Chamoli, Uttarakhand. It is situated 15 km away from Nanda Nagar (Ghat) Block Headquarters and 62 km away from district headquarter Gopeshwar. Dhurma – Kundi road is benefiting a population of approx. 1100 of following main beneficiary villages-

- Mokhmalla village is under Mokhmalla gram panchayat. The geographical area of Mokhmalla village is 230.24 hectares, total population is 694. It is approximately 12 KM away from Nandprayag.
- Kundi village is under Kundi gram panchayat. The geographical area of Kundi village is 162.66 hectares, total population is 381. It is approximately 25 KM away from Nandprayag.
- Dhurma village is under Dhurma gram panchayat. The geographical area of Dhurma village is 102.48 hectares, total population is 322. It is approximately 10 KM away from Nandprayag.

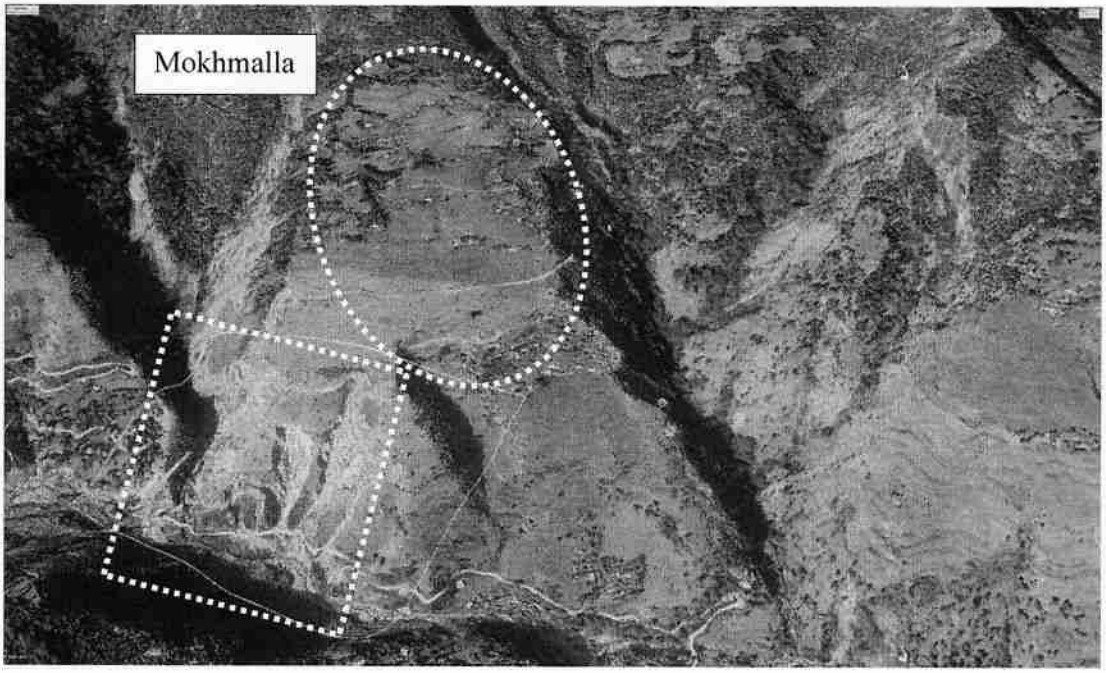

Figure 1: Google earth image showing locations of the village and road network

5. Geological Condition:

The area possesses a complex geological and geomorphological setup due to its close proximity to the Baijnath Thrust. It is mainly dominated by rocks of the Baijnath klippe. The road stretch is primarily composed of slope wash material, with some outcrops of folded and fractured quartzite (towards Nala where optional road has been constructed) (*Figure 2b, c*), rendering the slope susceptible to failure. Therefore, it is crucial to thoroughly analyze and evaluate slip circles to comprehend the conditions of slope instability/stability.

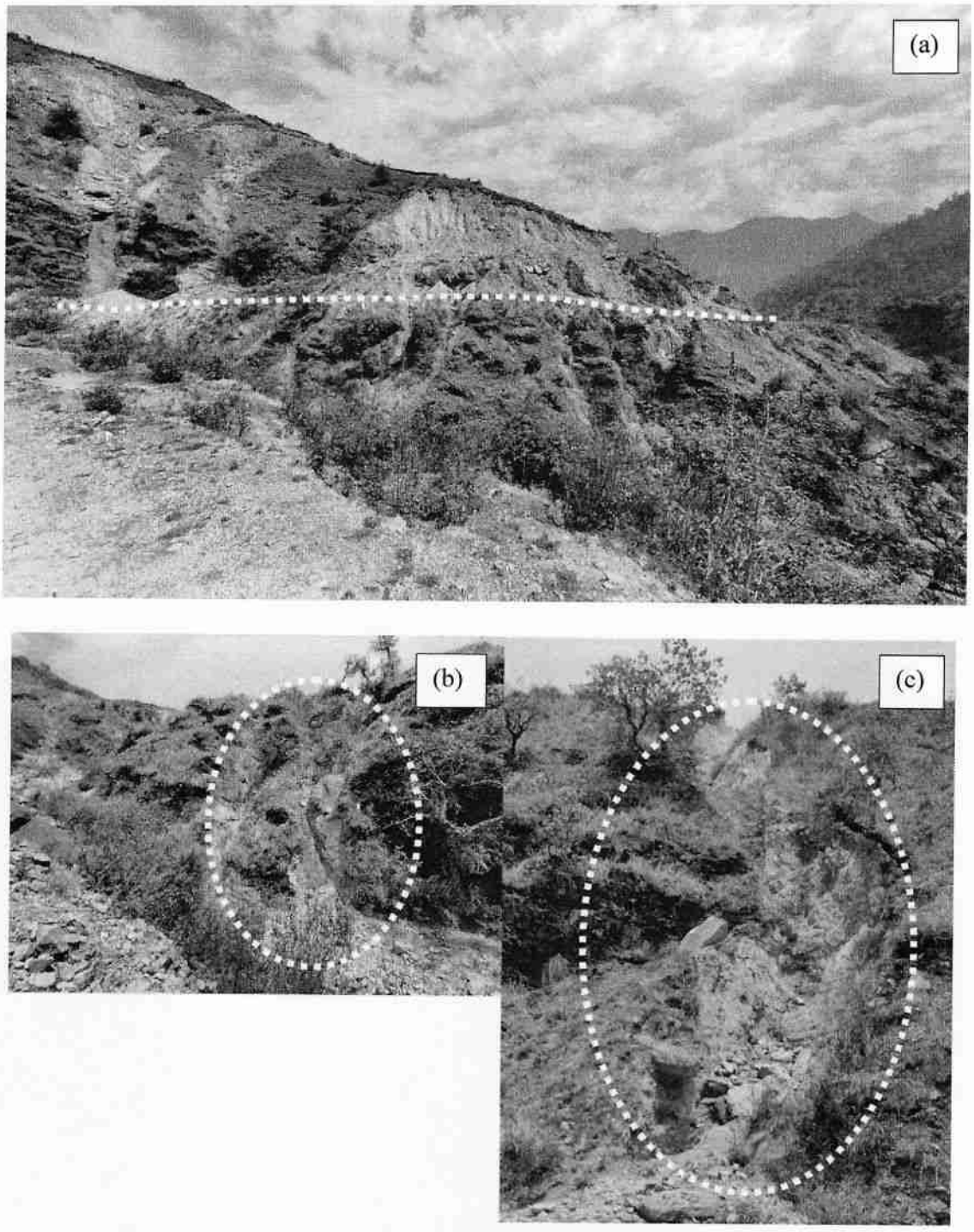

Figure 2: Figure showing (a) proposed road alignment location from the Nala Side slope, (b) and (c) fractured quartzite.

6. Background of the site

Following Satellite images (during Year 2018 to 2024) may illustrate the Morphology and chronology of slope degradation in terms of gradual erosion, gully formation and slope failure. It seems there is un-scientific road cutting on a steep and highly fragile (fractured rock) slope with multiple HP bends.

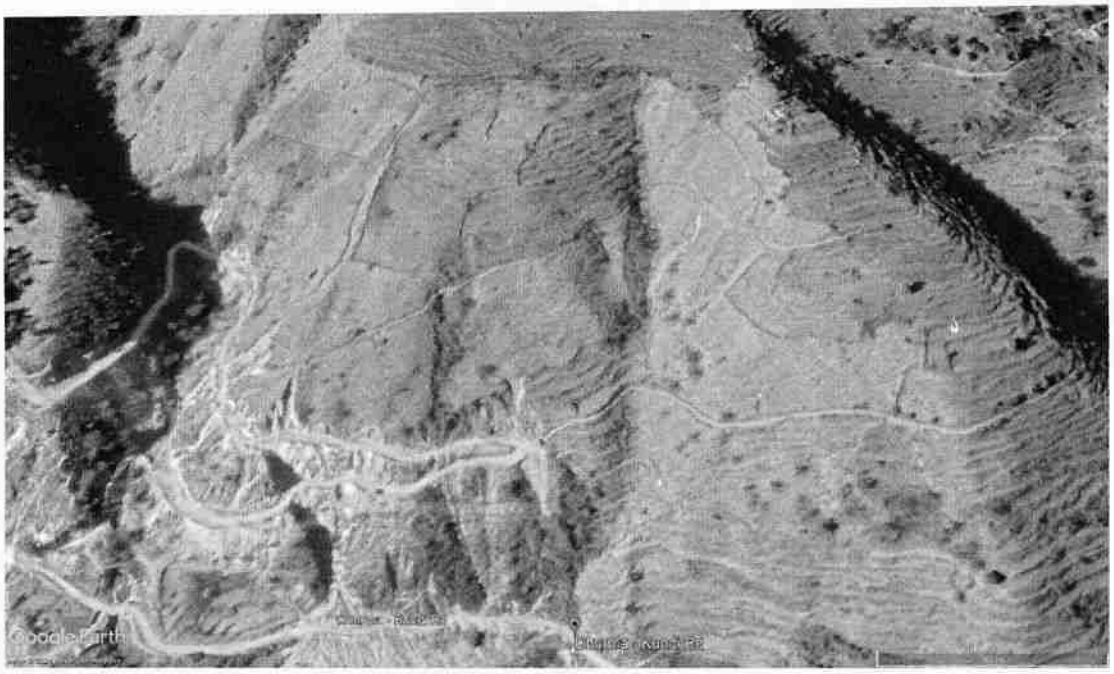

Figure 3-(a): Status of slope as on December 2018

Figure 3-(b): Status of slope as on December 2021

Figure 3-(c): Status of slope as on November 2023

Figure 3-(d): Status of slope as on January 2024

7. About the Project Proposal

i. In the year 2022-23 a heavy rain fall/ cloud burst occurred in the area and some of the portion (approx. 60 m) of the road at KM 2 has been washed away and about 100 m span fallen under a sliding zone.

PWD has evolved a project proposal for road re-alignment to restore the road connectivity with an estimated cost of Rs 60.07lakh. Salient features of Proposed Plan as follows-

1	Name of Project	राज्य आपदा न्यूनीकरण निधि (एस0डी0एम0एफ0) वर्ष 2023–24 के अन्तर्गत धुर्मा कुण्डी मोटर मार्ग के कि0मी0 02 में भूस्खलन से बचाव एवं सुरक्षात्मक कार्य।
2	Name of District	Chamoli
3	Name of Road	Durma – Kundi (Village Road) Total Length- 04 KM
4	Proposed Works	1) Hill side cutting 321 m length. 2) RR Dry Retaining walls in following manner- i. KM 2 Cross section 0/40-1/1- 30.00 m x 2.00 m ii. KM 2 Cross section 1/6-1/7- 20.00 m x 2.00 m iii. KM 2 Cross section 1/7-1/8- 25.00 m x 2.00 m iv. KM 2 Cross section 1/30- 18.00 m x 3.00 m v. KM 2 Cross section 1/32-1/34- 30.00 m x 4.00 m vi. KM 2 Cross section 1/35- 13.00 m x 2.50 m vii. KM 2 Cross section 1/40- 20.00 m x 2.00 m viii. KM 2 Cross section 2/2-2/5- 50.00 m x 3.00 m 3) Protection works through Gabions in following manner- i. KM 2 Cross section K/S (20 nos in 2 layers in 1/32-1/34) ii. KM 2 Cross section K/S (20 nos in 2 layers in 2/1-2/4) iii. KM 2 Cross section H/S (10 nos in 2 layers in 1/6-1/7) iv. KM 2 Cross section H/S (45 nos in 2 layers in 1/34-1/40) 4) Construction of Scupper (1 m span)- 3 nos 5) Disposal of excavated material from Hill side cutting.
5	Cost of Scheme	Rs 60.07 Lakh

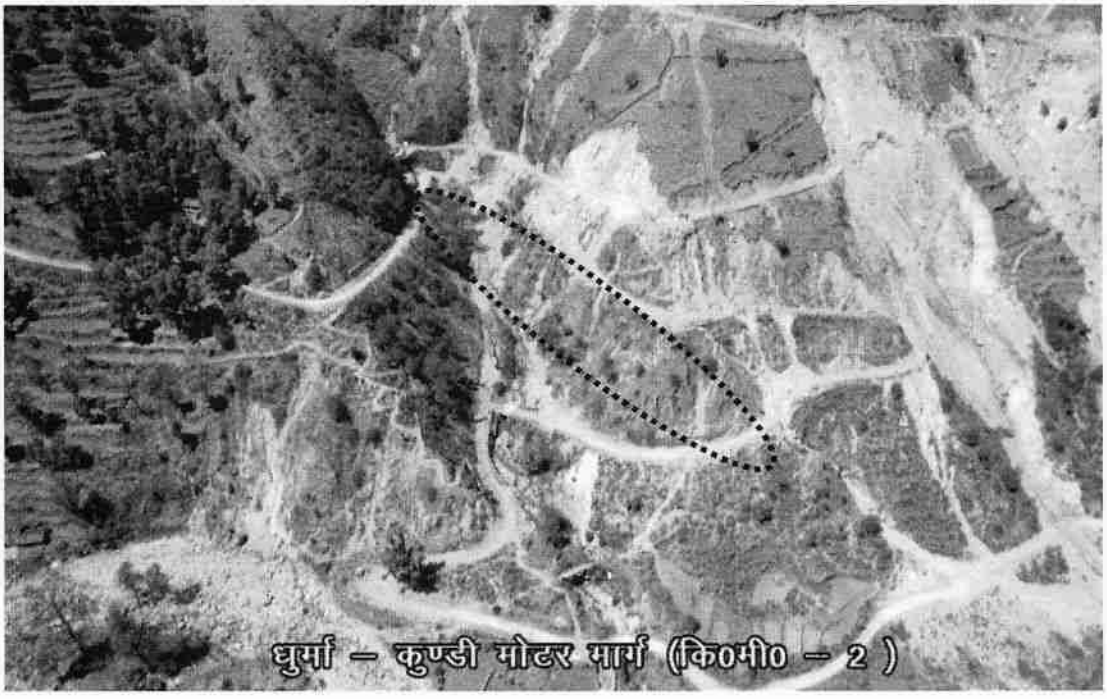

Figure 4: Proposed Road Re-alignment (Photo Curtesy to PDW Karnaprayag)

8. Site Details & Observations

Site Details:

- Approach: On Road Head. Diverted from Nandprayag-Ghaat Road.
- Type of problem: Road Washout due to slope failure.
- Total Length of Road: 04 KM (Village Road)
- Damaged length of the Road: 321 m at KM 2.
- Water body: Seasonal drains found adjoining.
- Agriculture: Arable land at proposed vicinity is rainfed and there is no source of micro irrigation.
- Habitation: Village Mokhmalla situated above the proposed site with a population of 694 (approximate) and dwellers engaged in Agriculture occupation.

Site Image

Figure 5: Over view of the Site

Observations:

- Approx 60 m road is completely washed out at KM 2 at Latitude 29.001148° & Longitude 79.675522°.
- Overburden and multiple road arcs on the upper slope. Constructing a road in such conditions may lead to the mobilization of the sliding zone, making the upper slope highly susceptible to failure, potentially resulting in a complete washout of the road network at the proposed location and its surroundings. (Figure- 3)
- Further, road passing through Point B to C, C to D and D to E is also on sliding zone which is highly susceptible to failure again. In such scenario, connectivity will again hinder.
- Village, Mokh Malla, situated on the slope above the road network.
- Drainage provision on road not found.
- This road is connected / link to another PMGSY road.
- It is also observed that previously installed protection works found damaged and no vegetation cover found on slopes even adjoining seasonal water body.

- Initial DPR and Contract Agreement for road cutting/construction were not made available.

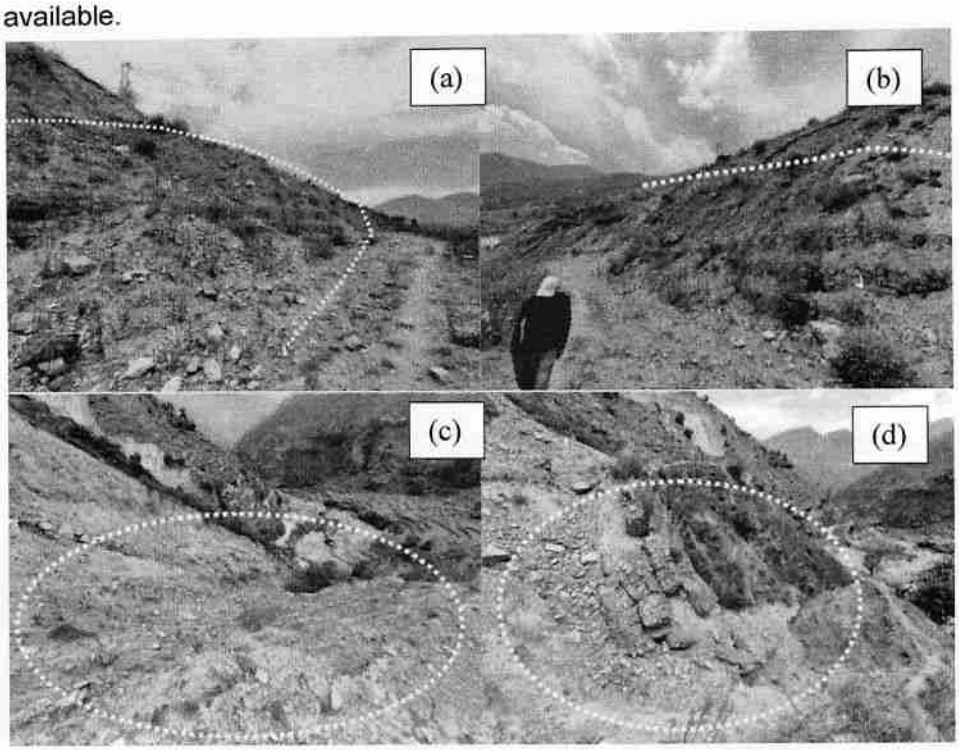

Figure 6: (a) and (b) showing proposed road alignment, (c) slope failure near proposed alignment, and (d) slope failure and damaged Gabions near proposed alignment.

9. Suggestions

i. Based on site observations, it has become crucial to evaluate the failure slip circle and the depth of the outcrop to design appropriate mitigation measures and finalise the road re-alignment.

ii. Considering the current situation, lowering the road alignment at proposed location may further trigger the slope failure again and retaining wall for existing road would not be sustainable.

iii. It is recommended to re-align the road from another/ alternative location with due consultation of panchayat & local governance.

iv. Relevant IS Codes, Topographic survey and Specific Geo- investigations (including kinematic analysis, rock and slope mass rating, geological mapping, folds & faults of the strata at slope, relevant Geo-technical and if required Geophysical investigations) shall be considered as mandatory for new site selection.

v. As per the proposal the gradient of new re-alignement is proposed as 1:20 however as per IRC 520:2019 for steep terrine for an elevation upto 3000 m it should be 1:16.7. Please review.

vi. As per enclosed Geology Report (conducted by PWD, dated 05-10-2021) reference of IS 1893:2002 (part-I) is taken however IS 1893: 2010 is latest. Please consider latest codes only.

vii. Design calculation and reference of IS Code, Road design with respect to traffic density & vehicle speed and muck management plan for new re-alignment is not mentioned in the submitted proposal.

viii. The seasonal drains/ surface run-off mainly influences of the area's hydrology & soil moisture that further effect overall slope stability including erosion, vegetation etc. In-adequate or poor drainage cause excess infiltration or increased runoff and lead to erosion. So, drainage provision must be there to ensure safe disposal of road run-off.

ix. Considering future, Green cover to check soil erosion at concerned slopes may be done by panchayat and Forest department.

x. Certificate of land ownership and land-use must be obtained from revenue department, as local dwellers and farmers, before new site proposal.

10. Conclusion

During the visit, the ULMMC team has assessed the Dhurma-Kundi Village Road at proposed site (KM-2). Transact walk, on site ocular observation, primary information source (from local public) and secondary information source (information lies with Public Department and Satellite Imageries) were used and came to the following conclusion-

In light of chronology of Satellite images (during Year 2018 to 2024) a gradual erosion, gully formation and slope failure can be seen clearly. It seems there is un-scientific road cutting on a steep and highly fragile (fractured rock) slope with multiple HP bends. Further, officials of PWD Karanprayag were unable to show the initial DPR for road cutting/construction which may include topographic survey, geological investigations, muck management plan etc. Such documents may provide ease to understand the status of strata before and after of road cutting.

Considering the current situation, lowering the road alignment at proposed location may further trigger the slope failure again and retaining wall for existing road would not be sustainable. In addition, site proposed for the road realignment (*Figure 4*) is deemed un-suitable due to overburden and multiple road arcs on the upper slope. A Geological Survey Report of this project (conducted by PWD on dated 16.07.2008) may also be referred. It seems the recommendations made in said Geological Report overruled during construction. Thus, it is recommended to re-align the road from another or alternative location with due consultation of panchayat & local governance.

In general, it is also suggested that the construction of new roads in Himalayan terrain must follow relevant IS Codes and should not proceed without Topographic survey and Specific Geo-investigations/analysis (including kinematic analysis, rock mass rating and slope mass rating), geological mapping, geotechnical analysis of materials (soil/regolith and rocks, California Bearing Ratio) and Geophysical investigation. Road Construction without proper investigation may increases the frequency of slope failures and allied disasters. With the changing climate, the risk of catastrophic events could be far greater than anticipated.

During the visit, Officials of Public Works Department Karanprayag facilitated the team. We express special thanks to Shri Sachin Kumar, Executive Engineer-PMGSY, Shri S K Rai, Geologist, PWD, Dr. Tushar Sharma, Geologist, PWD and Shri P L Dangwal, Junior Engineer, PWD Karanprayag.

(Vishal Rastogi)
Bio-engineering Specialist,
ULMMC, Dehradun.

(Dr Raghuveer Negi)
Geologist,
ULMMC, Dehradun.

Annexure

Site Visit: Dhurma- Kundi Road (KM-2), Nandanagar (Ghat), District - Chamoli, on 27.04.2024

Sliding Zone

Road Block

Road Block and Damaged Retaining Wall

Road Wash out

Road Block

Gully Formation

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Field Visit Report

Site: Churagad to Sutol-Kanol Road, Nandanagar (Ghat), District - Chamoli

Dated: 28-29 April 2024

1. Introduction:

A village road Churagad to Sutol-Kanol is situated under Nanda Nagar Development Block, Ghaat Tehsil of District Chamoli. The road is newly constructed to connect Kanol Village and other on route villages. The total length of said road is 11.60 KM and constructed by Public Works Department under PMGSY, in year 2020. The location of road is highly dissected mountainous terrain, elevation of the road ranges between 2056 to 2730 m. Due to excessive rain (year 2021-23), the road has been damaged/washout at multiple location and creating gullies and rills on the slope.

To restore the road connectivity, PMGSY Division Karanprayag has evolved following project proposal for road repairing (cost Rs 100.01 Lakh) and submitted under the State Disaster Mitigation Fund (SDMF) scheme-

"दैवीय आपदा के अन्तर्गत छुरागाड़ से सुतोल कनोल मोटर मार्ग के कि0मी0 6, 7, 11 एवं 12 में हुयी क्षतियों के पुनर्निमाण हेतु आवश्यक सुरक्षात्मक कार्य।"

2. Objectives/ Scope of Visit:

In compliance of Order No. 237/XVIII-B-1/2024-15(25)2021 dated 04/03/2024 issued by Director General, ULMMC, a team of following officials visited various sites at Sutol-Kanol Road on April 28-29, 2024, to examine the current status of site and to identify the scope of mitigation measures including Bio-engineering -

i. Shri Vishal Rastogi, Bio-Engineering Specialist, ULMMC, Dehradun.
ii. Dr Raghuveer Negi, Geologist, ULMMC, Dehradun.
iii. Shri Sachin Kumar, Executive Engineer, PMGSY, Karanprayag.
iv. Shri S K Rai, Geologist, PWD, Pauri.
v. Dr Tushar Sharma, Geologist, PWD Almora.
vi. Shri Pankaj Sajwan, Junior Engineer, PMGSY, Karanprayag.

3. About Nanda Nagar (Ghaat)

Ghat is a Tehsil, under District Chamoli and connected to Nandprayag on Rishikesh-Joshimath National Highway. On local public demand the name of concern town is changed to Nanda Nagar from Ghaat and accordingly name of Development block also changed to Nanda Nagar. It is approximately 280 KM away from State capital Dehradun.

Ghat Tehsil is an agricultural area and situated on the bank of river Nandakini in middle Himalayas. The area is often plagued by cloudbursts and landslides. Ghaat Block comprises total 97 villages with a total population of 37,408 and 7683 house holds.The SC and ST population is 22% and 1.2% respectively and has an average literacy rate of 76.6%.

4. About the Sutol-Kanol Road and Vicinity

Total length of Churagad to Sutol-Kanol motor road is 10.60 KM and estimated cost is about Rs 582.02 Lakh. Phase -I of Churagad to Sutol-Kanol motor road construction works were completed in the year 2020. The road is situated in Nanda Nagar (Ghat) Development Block of District Chamoli, Uttarakhand. The road is benefiting a population of approx. 1150 of following main beneficiary villages-

- Sitel village is under Sitel gram panchayat. The geographical area of Sitel village is 57.36 hectares, total population is 277 with Literacy rate of 63.18%. It is approximately 11 KM away from Nanda Nagar (Ghaat), 45 KM from sub-district headquarter Chamoli (tehsildar office) and 58 KM from district headquarter Gopeshwar.
- Sutol village is under Kundi gram panchayat. The geographical area of Sutol village is 404.66 hectares, total population is 459 with Literacy rate of 50.11%. It is approximately 35 KM away from Nandprayag. 75 KM from sub-district headquarter Chamoli (tehsildar office) and 85 KM from district headquarter Gopeshwar.
- Kanol village is under Kundi gram panchayat. The geographical area of Kanol village is 289.82 hectares, total population is 1153 with Literacy rate of 63.23%. It is approximately 32 KM away from Chamoli, 61 KM from sub-district headquarter Chamoli (tehsildar office) and 71 KM from district headquarter Gopeshwa.
- Loda village is under Loda gram panchayat of Tharali Tehsil, District Chamoli. The geographical area of Loda village is 49.6 hectares, total population is 175 with Literacy rate of 80.57%. It is approximately 10 KM away from Tharali, 59 KM from district headquarter Gopeshwar.

5. Geological Conditions

Geologically, the Sutol-Kanol section is situated between the rock sequences of the Baijnath Klippe and the Central Crystalline of the Higher Himalaya, delineated by the Baijnath thrust to the south and the Main Central Thrust (MCT) to the north (Figure 1). The crystalline rocks of the Higher Himalaya to the northeast are primarily composed of schists, gneisses, marbles, and basic intrusions, separated from the Lesser Himalayan rock sequence by the MCT. To the southwest, the rocks of the Baijnath Klippe are separated from the Lesser Himalayan sequence by the Baijnath Thrust. The Baijnath Klippe mainly comprises schists, augen gneiss, quartzite, amphibolites, and limestones.

The Sutol-Kanol section itself is predominantly composed of Mesoproterozoic age rocks of the Pithoragarh/Lameri Formation and the Chamoli/Berinag/Nagnithak Formation, which are part of the Garhwal Group. The Lameri Formation primarily consists of limestone, dolomite, shale, carbonate rocks, and phyllite/slate, while the Chamoli Formation is mainly composed of quartzite, slate, and metabasics.

The rocks observed along the road section are characterized by significant fracturing, jointing, crushing, and pulverization in many locations. The majority of the Sutol-Kanol road consists of slope wash material, overburden, and quartzite, making the area particularly susceptible to slope failures due to these geological conditions. Also, area is dominated with the Planner failure and circular failure.

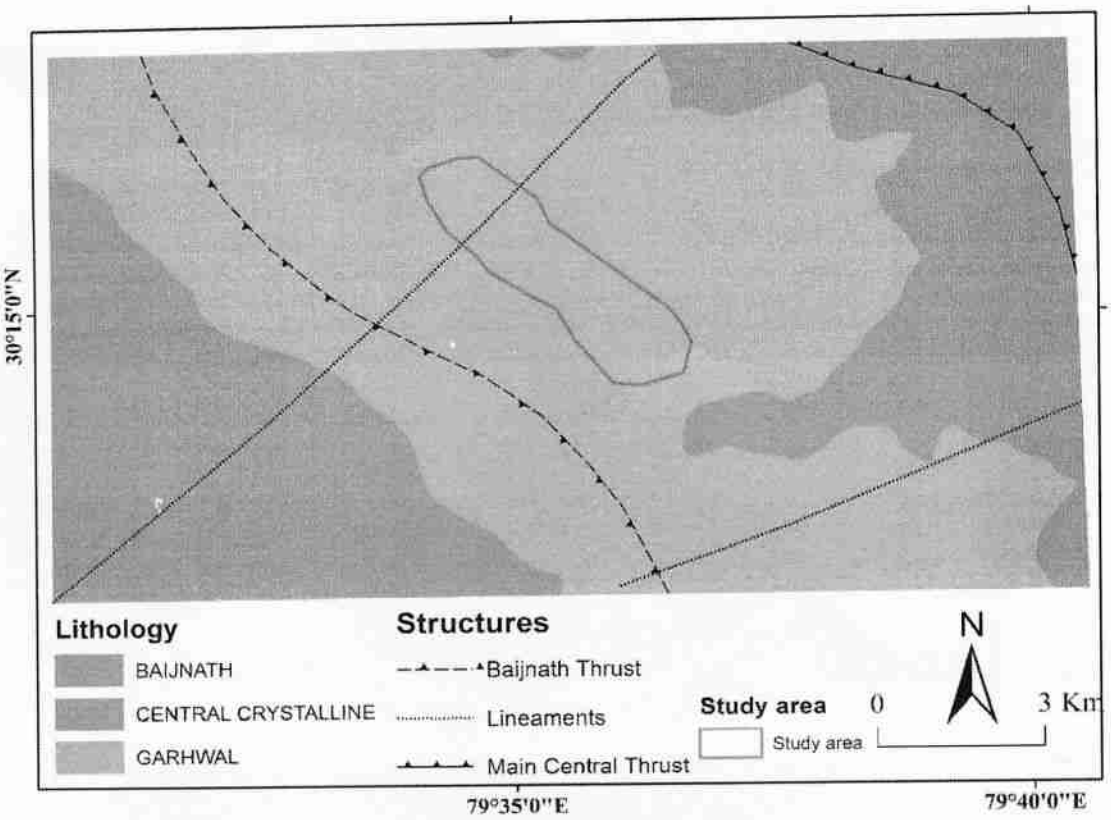


Figure 1: Geology of the Sutol -Kanol Road section and surroundings (after GSI, 2019)

6. Background of Site

Following Satellite images (during Year 2018 to 2024) may illustrate the Morphology and chronology of slope. Widening of existing gullies and slope washout/ muck clearly can be observed. The road construction was carried out in year 2020-21 and corresponding image of 2021 & 2022 depicting the comparative degradation. It seems there is un-scientific road cutting on a steep and highly fragile slope with multiple HP bends.

Figure 2-(a): Status of slope as on Nov 2018

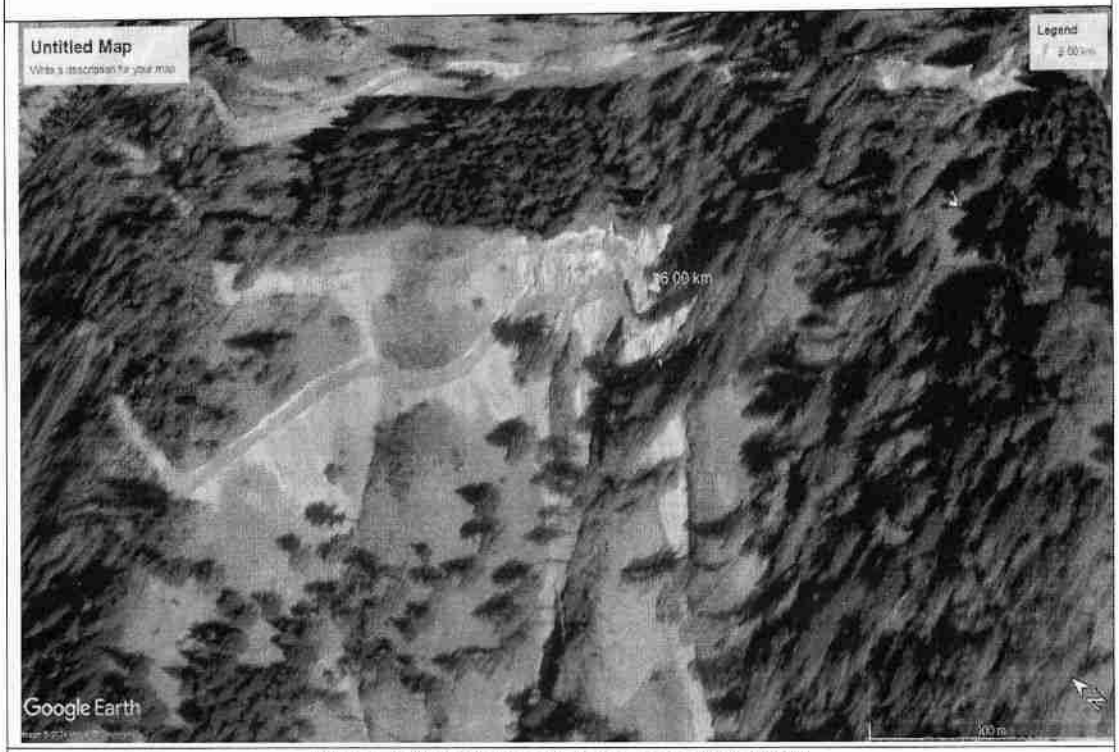


Figure 2-(b): Status of slope as on Feb 2021

Figure 2-(c): Status of slope as on Oct 2022

Figure 2-(d): Status of slope as on Nov 2023

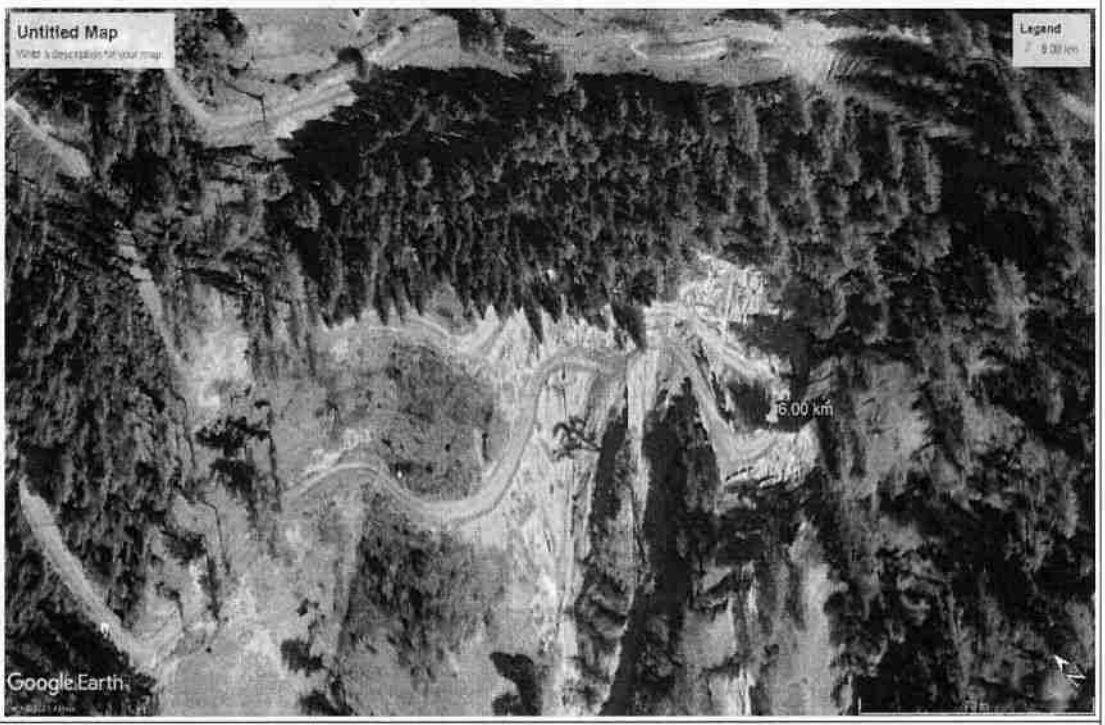


Figure 2-(e): Status of slope as on Jan 2024

7. About the Project Proposal

In the year 2022-23 a heavy rain fall occurred in the area and some of the portion of the road at km 06, 07, 11, and 12 has been damaged/washed away. To restore the road connectivity, PMGSY Division Karanprayag has evolved following project proposal for road repairing; worth Rs 100.01 Lakh and submitted under the State Disaster Mitigation Fund (SDMF) Scheme-

"दैवीय आपदा के अन्तर्गत छुरागाड़ से सुतोल कनोल मोटर मार्ग के कि0मी0 6, 7, 11 एवं 12 में हुयी क्षतियों के पुनर्निमाण हेतु आवश्यक सुरक्षात्मक कार्य।"

Salient features of Proposed Plan as follows-

1	Name of Project	दैवीय आपदा के अन्तर्गत छुरागाड़ से सुतोल कनोल मोटर मार्ग के कि0मी0 6, 7, 11 एवं 12 में हुयी क्षतियों के पुनर्निमाण हेतु आवश्यक सुरक्षात्मक कार्य।
2	Name of District	Chamoli
3	Name of Road	Churagad to Sutol-Kanol (PMGSY Road) Total Length- 10.60 KM
4	Total Length to be repaired/mitigated	321 m (including all the patches)
4	Proposed Works	1) RR Breast Wall 2) RR Retaining Wall 3) Plum Concrete & Gabion Wall 4) Drainage & Causeway
5	Cost of Scheme	Rs 100.01 Lakh

8. Site Details & General Observations

Site Details:

- Approach: On Road Head. Diverted from Nandanagar (Ghaat).
- Type of problem: Road Damage/Washout due to erosion/slope failure.
- Total Length of Road: 10.60 KM (PMGSY Road)
- Damaged length of the Road: Total 321 m in multiple patches at KM 6,7,11 & 12.
- Water body: Not found adjoining the road.
- Agriculture: Arable land at proposed vicinity is rainfed and there is no source of micro irrigation.
- Habitation: Village Sitel, Sutol, Kanol and Loda situated on the proposed road with a sum of population 1150 (approximate) and dwellers engaged in Agriculture occupation.

General Observations

- The area possesses rugged topography and steep slopes, which predominantly exhibit circular failures (*Figure 3*).
- A substantial portion of the road traverses through slope wash material and pulverized rocks, which contributes to the instability and potential for slope failure.
- The area is experiencing creep, as evidenced by the tilted trees (Figure 4). The figure shows the tilting of trees between KM 6-8, illustrating the ongoing geomorphic processes ground movement.
- Muck dumping is not found in accordance to EC/Muck Management plan.
- Compensatory afforestation could not be located.

Figure 3: Slope failure (Circular failure) along the Sutol - Kanol road between KM 06 and KM 07.

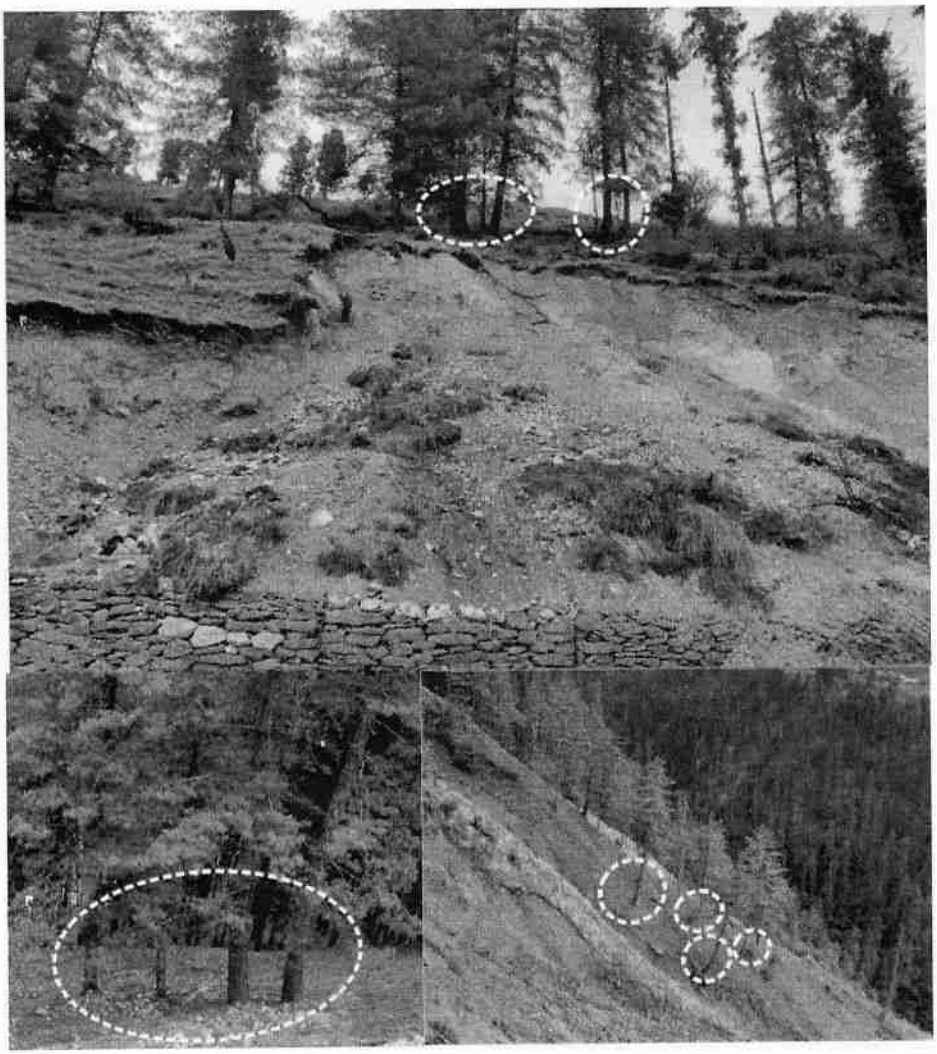


Figure 4: Tilting of trees between KM 6-8 of Sutol-Kanol road, demonstrating impact of tectonic and geomorphic processes on the slope.

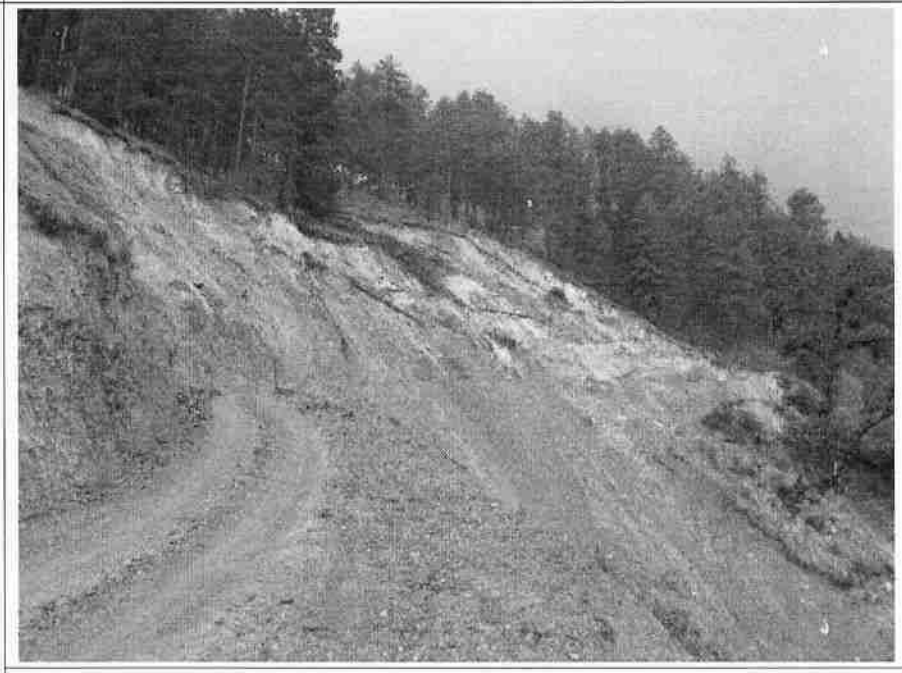
9. General Suggestions

- Specific Geo-investigations (eg- kinematic analysis, rock and slope mass rating, geological mapping, relevant Geo-technical and if required Geophysical investigations) must be conducted just after survey and before road cutting. So that, post construction damages may avoid or preparedness may develop for mitigation.
- Stability analysis of proposed structures must be carried out. Allied investigations/ tests may be helpful for the same eg- SBC, CBR etc.
- Relevant IS Codes, Road design with respect to traffic density & vehicle speed, muck management plan and relevant geo-investigations shall be considered before new road construction.
- The gradient of existing road is described as 1:20 however as per IRC 520:2019 for steep terrine for an elevation upto 3000 m; it should be 1:16.7. Please review.
- As per the site conditions mitigation measures for vulnerable sections must be designed as light weight, sturdy and constructed by using local available material.
- Nature-based solutions including Bio-engineering Measures may be applied viz. Coir/Jute net with suitable grass or NTFP species to check erosion.
- Hydrological Factor-

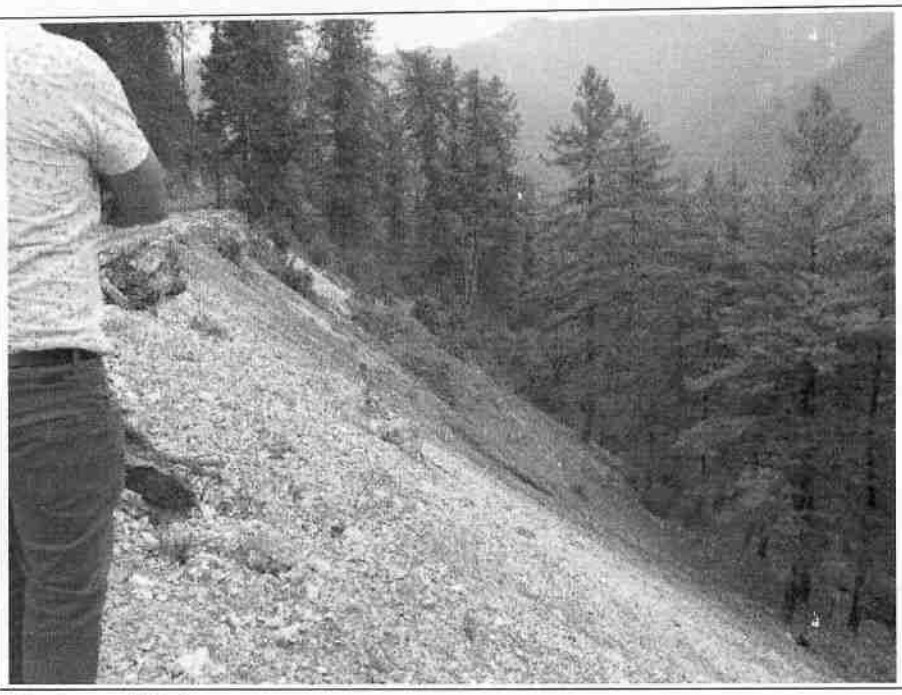
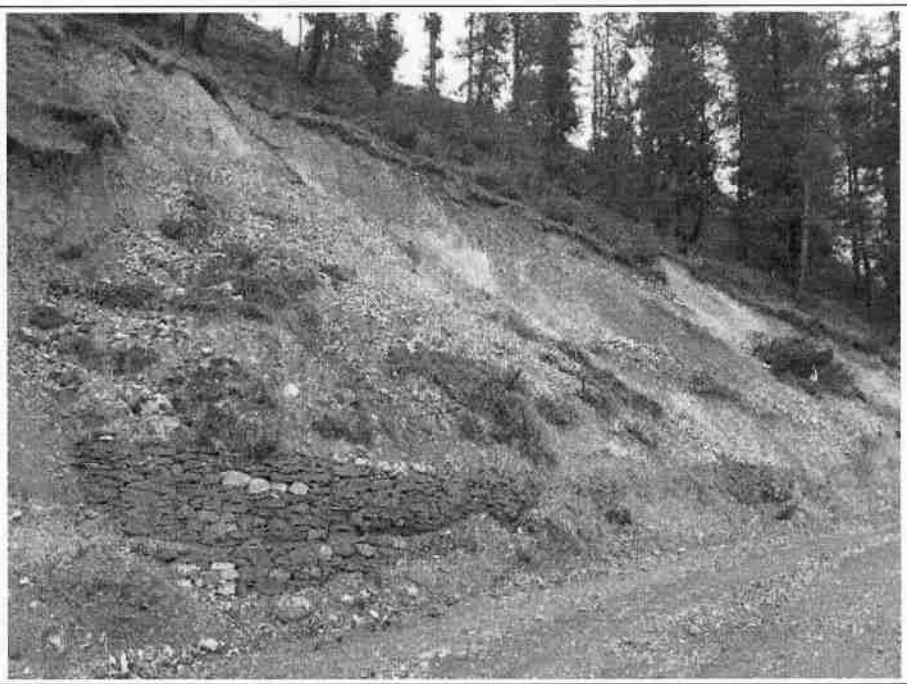
  Water is recognized as an important factor in erosion control/slope stability-almost as important as gravity. The seasonal drains/ surface run-off mainly influences of the area's hydrology & soil moisture that further effect overall slope stability including erosion, vegetation etc.

  Since precipitation and run-off is considered as triggering factors for erosion, it is important to check run-off and channelize it for safe disposal. So, it is crucial to drainage of culverts & road/surface run-off through catch drains and vertical drainages even flexi drains etc. The mostly length of the road requires a safe run-off disposal to check erosion/ slope failure.

10. Spot Specific Suggestions

S. No.	Description
1	
	Status: Road widening required through Retaining Wall. Suggestion: Slope is covered with Slope wash material and in a deep valley. Specific geo technical investigations eg- SBC, DST & grain size would be helpful to find out best suited solutions.

2	
	Status: Hill side slope protection required. Suggestion: RR masonry/ banded Breast wall may be used with weep holes. Above said structures grasses, ringal and other NTFP may be used.
3	
	Status: Hill side valley side (between 2 arms of the road) slope protection required. Suggestion: Hill side: Gabion (2 layers in step) above gabions NTFP Plantation. Drain construction to ensure safe disposal of road run-off. The run off may be disposed at the HP bend through a flexi vertical drain at minimum 150 m downwards at stable strata. Valley side (between 2 arms of the road): HP Stone filling between road and protection structures placed at lower arm.

4	
	Chainage: KM 8 Status: Slope protection on Valley Side required. Suggestion: Valley Side Vegetative fencing, Coir net with grasses till trees.
5	
	Status: Hill side slope protection required. Suggestion: RR/ banded Breast wall may be used. Above said structures grasses, ringal and other NTFP may be used.

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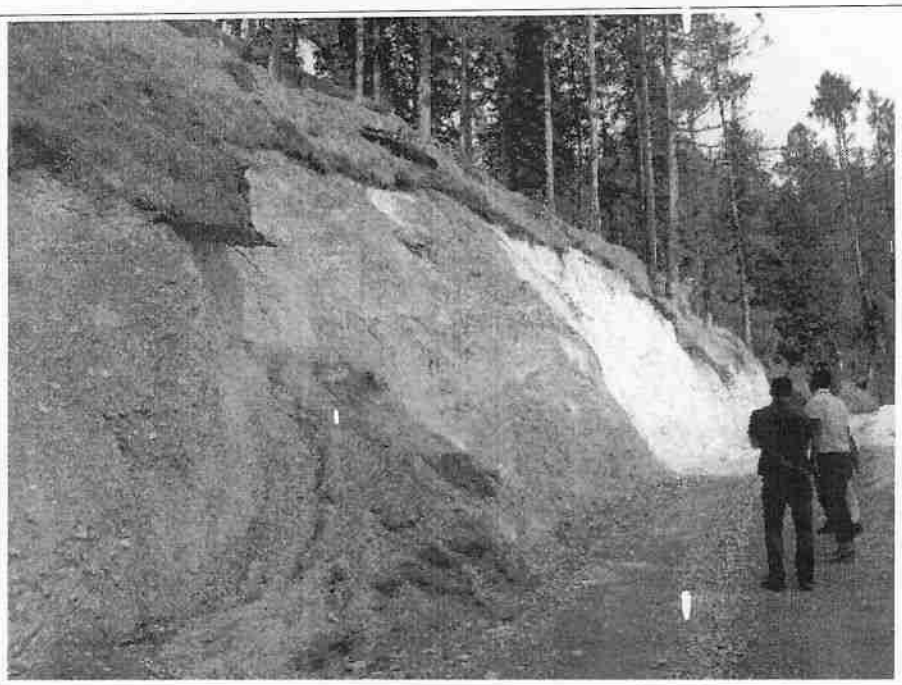
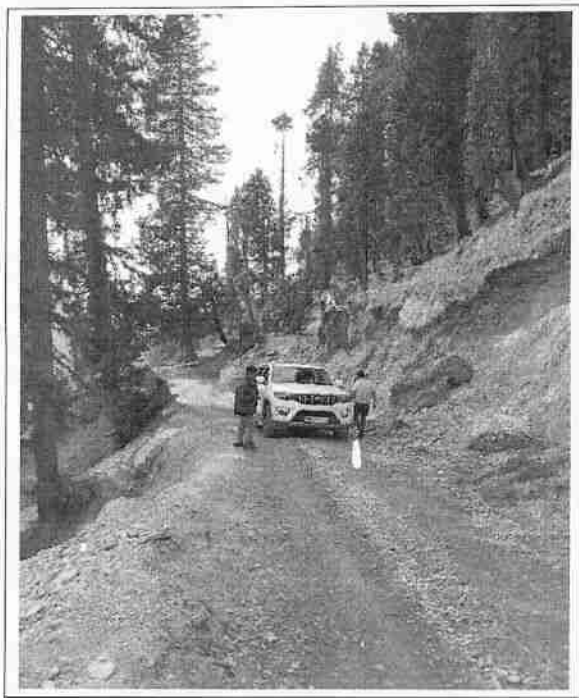
6	
	Status: Hill side protection required. Suggestion: RR / banded Breast wall may be used.
7	
	Status: Slope protection required. Suggestion: Remove aggregate from the Slope. Vegetative fencing along the road. Coir net with grasses + NTFP.

	
Status: Hill side slope protection and valley side retaining required. Suggestion: Remove loose material. RR/ Banded Breast and Retaining wall with weep holes may be used.	Status: Hill side slope protection required. Suggestion: Remove loose material RR/ Banded Breast wall with weep holes may be used.
	
Status: Road widening at top required. Suggestion: Vertical Drain must be connected to the culvert placed on upper & lower arm of the road, up to river at bottom (estimated vertical drain length 200 m). Breast wall by using gabion (2 layers) +Coir net with grasses & NTFP.	Status: Road widening at top required. Suggestion: Shift crate wire/Gabions towards hill side and make upto the road in steps. HP stone filling must be used between road and Gabions. Road run off should not be on this slope.

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11. Conclusion

During the visit, the ULMMC team has assessed various sites at Sotol-Kunol Road. Transact walk, on site ocular observation, primary information source (from local public) and secondary information source (information lies with Public Department and Satellite Imageries) were used and came to the following conclusion-

In light of chronology of Satellite images (during Year 2018 to 2024) may illustrate the Morphology and chronology of slope. Widening of existing gullies and slope washout/ muck clearly can be observed. The road construction was carried out in year 2020-21 and corresponding image of 2021 & 2022 depicting the comparative degradation. It seems there is un-scientific road cutting on a steep and highly fragile slope with multiple HP bends.

Considering the current situation of proposed sections of the road, it appears that the road alignments were not developed as per Geological, Geomorphological, and Slope Characterises. The current road alignments seem overly complicated and may not be sustainable in terms of long-term stability.

It is suggested to re-frame the project proposal after conducting specific geo-investigations (Kinematic analysis, Slope Mass Rating and Geological mapping of the road section on 1:2000 m scale, Grain size analysis, CBC and DST) and assessment of major structure (folds & faults). Further, in accordance with the site conditions mitigation measures for vulnerable sections must be designed as light weight, sturdy and constructed by using local available material and nature-based solutions. Some of the mitigation measures already suggested in this report.

In general, it is also suggested that the construction of new roads in Himalayan terrain must follow relevant IS Codes and should not proceed without Topographic survey and Specific Geo-investigations/analysis (including kinematic analysis, rock mass rating and slope mass rating), geological mapping, geotechnical analysis of materials (soil/regolith and rocks) and Geophysical investigation. Conducting these investigations before road cutting in the Himalayan terrain may help in better infrastructure development and significantly reduce the chances of slope failure/ slope stability issues & allied disasters.

During the visit, Officials of PMGSY, Karanprayag facilitated the team. We express special thanks to Shri Sachin Kumar, Executive Engineer-PMGSY, Shri S K Rai, Geologist, PWD, Dr. Tushar Sharma, Geologist, PWD and Shri Pankaj Sajwan, Junior Engineer, PMGSY, Karanprayag.

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