

परियोजना का नाम:- उत्तराखण्ड राज्य के जनपद रुद्रप्रयाग में राष्ट्रीय राजमार्ग-07 (पुराना एन0 एच0-58) के कि0मी0 399.000 से कि0मी0 460.000 में लैंडस्लाइड का उपचार सहित सड़क का चौड़ीकरण एवं सृढढीकरण हेतु राष्ट्रीय राजमार्ग एवं अवसंरचना विकास निगम लिमिटेड का वन भूमि हस्तान्तरण प्रस्ताव।

प्रारूप-33

परियोजना के निर्माण हेतु भू-वैज्ञानिक की आख्या

प्रमाणित किया जाता है कि विषयगत परियोजना के निर्माण हेतु भू-वैज्ञानिक की आख्या संलग्न कर दी गयी है।



महाप्रबंधक (परियोजना)
राष्ट्रीय राजमार्ग एवं अवसंरचना विकास निगम
लिमिटेड, देहरादून उत्तराखण्ड
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CONCLUSION AND RECOMMENDATION

The study area lies in the Uttarakhand Lesser Himalaya and includes the area of Chamoli District of the Uttarakhand. Geologically, the study area consist of the six formations of Mussoorie group and Jaunsar Group from bottom to top these formations are Subathu Formation, Mandhali Formation, Chandpur Formation, Balaini Formation, Infra Krol Formation Krol Formation and Tal Formation. Mussoorie group of rock is tectonically contact with MBT at north and comprising dark grey to black shale with interbedded limestone, dolomite, diamictite quartzite etc. Mussoorie group of rock is overlain by Mandhali and Chandpur Formation of Jaunsar Group, Which has been separated by North Almora Thrust, also called as Dharasu Thrust. Jaunsar Group of rock consists essentially of phyllite and quartzite with occasional slate, limestone. The alignment studied between 368+000 km and 528+000 Km of the Rudraprayag to Mana, Road lies in the Outer Lesser Himalaya. The road is aligned through the Damtha and Tejam Groups of rocks. The road crosses several perennial nallas and seasonal streams with the bridge and culvert over them. Most part of the road is aligned through the rocky hill slope and rest of the road is aligned through residual soil, debris and old alluvium deposit. Some of the stretch of the road is aligned through cultivated land and settlement. Almost all part of the road is aligned through middle slope and lower slope of the hill.

Project road section falls on the low hazard zone. Negligible part of the road is aligned through the rock slope and falls under the category of medium hazard zone. Most of the unstable part of the Road is due to high cut slope, fragile rock strata, and loose debris/old alluvium deposit and road alignment parallel to bedding strike.

There would be some major problem for widening the project road alignment from km 395+000 to km 398+000 (Karnaprayag), where the existing road is very narrow with high gradient hill slope of hard rock geology and some locations are also of half tunnel cut in hard rock after Lambahgarh near Balram iron bridge, Govindghat-I, etc.

During the period of the road widening, existing naturally stable hill slopes would become unstable due to huge excavation. Thus suitable slope stabilization measures, as per site condition, must be planned and initiated in the excavated hill side area during road widening. Thus broad treatment measure required to stabilize the hill slope include:

- Grading of the slopes in the crown region. The slopes may be designed after taking into consideration the properties of the material occupying the slopes. Recommended slope cut on rocks and overburden (H: V) has been provided in Litho-units Inventory table. However, final slope cut shall be decided as per site condition and location topography.
- Strengthening of toe by provision of a toe wall. Since it appears that bedrock is expected to be available at shallow depth in this region, the restraint structure can be anchored with the bedrock.
- Slope cut on the loose soil can be stabilized by using the simple Bioengineering Techniques with combination of minor civil engineering structures. The effective bioengineering technique recommended for bioengineering site are combination of Jute netting and diagonal grass line, the contour grass lines or Jute netting and randomly planted grass, down slope grass lines and vegetated stone pitched rills, shrub or tree planting, turfing.
- Prevent slope by shotcrete and grouting as well as rock bolting / soil nailing as per site condition and the types of material and landslide.
- Provision of surface drainage with a view to minimize the ingress of same into subsurface.

Jasbir Abbot



INTRODUCTION

Geological Assessment has been carried out for Rudraprayag – Mana road alignment, located along Rudraprayag (368.000 km) to Mana (528.000 km) NH-58 road section.

Landslides along communication routes in Himalayan region are very common disrupting the life and property of people, besides immensely affecting communication networking. Slides occur due to various causes which include geological, geomorphological and hydrological factors.

Geological traverses have been taken to locate the existing small and big landslides and rock fall zones with the help of GPS and also collected all required data. The present work is the outcome of one week of field work and one week of desk works.

The study focuses mainly on the geotechnical studies of the road alignment by identifying and classifying of the landslides area as well as the causes of the slope instability and its prevention methods.

LOCATION AND ACCESSIBILITY

The study areas lie in the Chamoli District of the Uttarakhand. The project area is about 368 km towards NNE to Rudraprayag from New Delhi. Geographically it lies in the northern flank of Outer Lesser Himalaya of Uttarakhand. The study area falls within topographical map and its co-ordinates are given in below **Table 1**:

Table 1: Location details of Project road alignments

Road Section	District	Road Distance (km)	Series U502, U.S. Army Map Service, 1955	Area lies
Rudraprayag - Mana	Rudraprayag & Chamoli	160	Dehradun NH-44-5	East longitude 79° 02' 39" & 80° 03' 29" North latitude 29° 55' 00" & 31° 03' 45"

The study area is linked by a motorable road. The road is black topped and is an all weather motorable. There are many tracks connecting local villages that make the area accessible.

OBJECTIVE AND METHODOLOGY

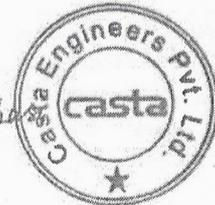
OBJECTIVE

The Overall objective of the study is to study the geology and evaluate the Geotechnical status of the landslide / slope instability zones along road alignments between Rudraprayag – Mana to gain the techniques about instable slope treatment and its protective measures during the period of NH-58 widening.

METHODOLOGY

Geological field studies and geotechnical investigation of the project road alignment are usually performed by different approaches in methodology. Most of the methods applied by engineers are functional and lack basic geotechnical tests and broad survey. So it has been found necessary to conduct engineering geological mapping. Landslides / unstable area have been marked with the help of co-ordinates using Garmin Oregon Series GPS and digitized maps.

Farhan Abbas



REGIONAL GEOLOGY AND GEOLOGY OF THE STUDY AREA

TOPOGRAPHY

The area is a part of Lesser Himalaya. Topography seems to be controlled by the structure and lithology. While the sound rock quartzite, limestone and phyllite form steep slope. In general the valleys are 'U' Shaped, however at places 'V' Shaped valley are also found. In general the strike of the ridges follows the strike of the formation have NW-SW strike the ridges also trend in that direction and when the strike of the rocks become NE-SW, the ridges also assume the same pattern.

PHYSIOGRAPHY

Physiography of Uttrakhand is closely related to geology and structure and can be divided into two distinct physiographic divisions (Gopendra Kumar, GSI, 2005; Geology of Uttar Pradesh and Uttaranchal),

1. Indo-Gangetic Plain in the middle, and
2. Himalaya in the north

HIMALAYA

The Himalayan segment forms part of the 2500km long and about 250km wide belt of mountain ranges which stretches from Nanga Parvat in Jammu and Kashmir in the west to Namcha Baruwa in Tibet in the east. It abuts against the Mishmi Hills along the Tidding Suture in the east. The Tibetan Plateau borders it in the North while the Indo-Gangatic-Brahmputra Plains form its southern limit.

The Himalaya has been divided into four linear east- west trending physiographic zones, viz. the Outer or Sub - Himalaya , Lesser Himalaya, The Great Himalaya , and the Tethys (Tibetan) Himalaya .

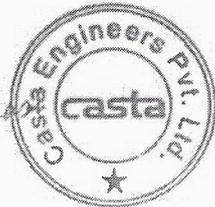
Sub-Himalaya is the southernmost one comprising chiefly of Cenozoic sediments-the Siwalik Supergroup, and is also called as Siwalik Range. It rises abruptly the Indo-Gangatic Plain along the HFT and is limited by Lesser Himalaya along MBT in North and largest duns, extending from Kalsi in the west to Ganga valley in the east.

Lessser Himalaya is a broad zone that lies between the sub-Himalaya in the south and the Great Himalaya in the south and the Great Himalaya in the North, and comprises mainly of thick proterozoic sequences, excepting a narrow zone of early Cambrian succession along its southern part close to the Sub-Himalayan zone. This attains heights between 1200m to 3000m. The MBT and MCT define its southern and northern limits.

The Great Himalaya is narrow zone that lies between the lesser Himalayan in the south and the Tethys in the North, and is chiefly made up of Archean - Palaeoproterozoic sequences constituting the Central Crystalline and Mesoproterozoic - Dar Formation, which forms the basement for the Phanerozoic succession of the Tethys Himalaya. This is limited by MCT in south while in the north, it imperceptibly passes into the Tethys Himalaya, through at places a tectonic plane. The main relief varies varies between 4800m to 6000m. This zone is characterized by highly rugged topography with snow bound peaks. It hosts a number of glaciers.

Tethys Himalaya is the northernmost subdivision of the Himalaya that imperceptibly passes from the Great Himalaya that lies to its south. The ISTZ (Indo-T sangpo Suture Zone) separates it from the Trans- Himalayan zone in the north. It is chiefly made up of phanerozoic rocks and is characterized by anticlinal ridges and synclinal valleys. It attains heights of 3500 m to 4800 m.

Jorhan Abbas



INDO-GANGETIC PLAIN

Indo-Gangetic plain is the largest alluvial plain in the world occupying an area of 700,000 km², of which about 223,000 km² lies in Uttar Pradesh and part of it in Uttarakhand, and is referred to as the Ganga Plain. The plain forms a featureless undulatory surface with an average gradient of about 34 cm / km towards southeast. It lies between the Himalaya in the north and the peninsular upland in the south. In Uttar Pradesh, it is limited by the Yamuna river in the west and continues eastwards through Bihar to west Bengal. This is very limited in Uttarakhand and is found towards the southern end of the state.

GEOMORPHOLOGY

The Uttarakhand Himalaya exhibits a variety of geomorphic features, which give distinctive characteristics to each geological unit, namely Higher Himalaya, Lesser Himalaya and Outer Himalaya. The Bhagirathi River, originating from Gangotri Glacier in Gaumukh, and the Alaknanda River from Satopanth Bhagirath Kharak group of glaciers of Himalaya, form broad U-shaped valley in their upper reaches. Downstream they cut deep V-shaped gorges while flowing through Greater and Lesser Himalayan terrain. The main rivers are fed with numerous small first and higher order streams from both sides. They cut through a variety of lithologies with variable structural features, and deposit glacial, glacio-fluvial and fluvial sediments.

- i) Lesser Himalayan Seismic Block: This crustal block lying between the MBT in the south and MCT in the north has highest seismicity level with source faults as thrusts trending parallel to Himalayan trend. The epicentral location in this block is concentrated close to MCT.
- ii) Frontal Hill Seismic Block: This crustal block to the south of MBV upto HFT and beyond, includes also a number of thrusts and transverse tear faults in the foothill belt. These longitudinal and transverse fault surfaces are neotectonically active.

The landforms in the area are structural, glacial, fluvial, and denudation in origin. Inversion of relief in highly metamorphosed rocks, in the north, reflects the impact of high rate of erosion process on long term scale of millions of years in the area. Rapid tectonic uplift, intense fluvial and glacial incision produce long steep slopes (Shrader and Bishop, 1998). Common geomorphic features are the cliffs, rocky slopes, waterfalls, major and minor ridges and Quaternary deposits along the hill slope and the river valley are: highly dissected denudation hills, moderately and low dissected denudation hills, river terraces, and various fluvial geomorphic features like point bar, meandering scars, natural levees, terraces (Chakraborty, 2007).

The effect of high relief and structural control is reflected by deep gorges and wide valleys carved by numerous channels. The river bed gradients are in general steeper (20m/km) in the Greater Himalaya and in parts of Lesser Himalaya. It becomes gentler (15m/km and less) southwards, in general. The loose Quaternary deposits and other sediments and old rock falls, landslides, glacial, periglacial and hill slope scree process generally cover the middle valley slopes. The thickness of these deposits varies from 2m to more than 15m depending upon the slope angle, aspect and bedding plane of the parent rock.

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DRAINAGE SYSTEM

The rivers of Uttarakhand belong to Ganges drainage system. Of these, the Alaknanda, Ganga, Rishi Ganga, Kkirao Nala and are the main glacier fed rivers, which originate in the higher Himalaya or the Tethys Himalaya. The Rishi Ganga and Ganga originate in the Lesser Himalaya.

The Bhagirathi rising from the Gangotri Glacier near Gaumukh in the Tethys Himalaya and has broad U-shaped valley upstream of jhala in the upper reaches, but cuts across the Great and Lesser Himalaya in a narrow V-shaped gorge. It swings to west near Uttarkashi and further downstream takes a U-turn to assume an easterly flow. At Tehri, it is joined by another glacier-fed river – the Bhilllangana, and flows southwards cutting a gorge.

GLACIERS

River Alaknanda is a perennial and covers a large area glaciated of Uttarakhand. The Satopanth glacier, which flows longitudinally from the northern slopes of the Chaukhamba peaks down to the Gaumukh in a WNW direction, is the longest (28 km) glacier occupying an area of about 50 sq. km in Central Himalaya. It is fed by a number of tributary glaciers such as the Kamet, Mana, Swetvarna, Chaturangi, etc. These glaciers are named depending upon the colour of the surrounding rocks. The Satopanth glacier ends with a large cave at the snout at Gaumukh from where the Bhagirathi River gushes out. It has two well developed lateral moraines all along the glacier such as those seen at Tapovan and Nandanvan, 5 and 7 km upstream of Gaumukh and about 200 m above the glacier. The glacier has retreated for about 600 m between 1935 and 1967. From Gaumukh to the Satopanth Temple, the valley is wide and U-shaped. According to the International Center for Integrated Mountain Development (ICIMOD), 2011 published. "The Status of Glaciers total 374 numbers of glaciers are exist at and around Satopanth Glacier area. Amongthem, Bhagirathi glacier covering the area 262.53 sq.km. is the largest glacier.

REGIONAL GEOLOGY

Uttarakhand is a hill state, most of which occupies a part of Himalaya stretching about 320 km between Himachal Pradesh in the west and Kali River in the east, forming the Indo-Nepal border.

The Himalaya is a young and dynamic orogenic belt with rising mountain ranges. It trends roughly east-west for about 2400 km width span varying between 325-425 km. The Himalayan terrain owes its origin to the collision of north to north-eastward moving Indian lithospheric plate, with the Asian plate in the north at about 56 Ma (Patriat and Achache, 1984, Molnar, 1986) and thus forms a continent-continent collision type orogenic belt (Valdiya, 1984).

The Himalayan from north to south is divided into five distinct geological units based on tectonic and lithologic discontinuities and separated by major Himalayan thrust faults dipping northwards (Wadia, 1957; Ganssner, 1964; Valdiya, 1980; Powers et al., 1998) (Figure 1 & 2). Each unit has its own geotectonic and seismotectonic characters. The major geological units and thrust faults control the present morphology of the Himalayan ranges.

THE TRANS-HIMALAYA

The Trans-Himalaya consists of volcanic, plutonic, and metamorphosed Precambrian-Mesozoic rocks. The southern limit of this is marked by the Indus Tsangpo Suture Zone (ITSZ), which defines the zone of collision between the Indian and Asian plates. The ITSZ comprises of ophiolites and ophiolitic mélangé, fore-arc sediments and a magmatic arc consisting of plutonic-volcanic rocks of Cretaceous to Early Tertiary age (Corfield et al., 1999). The ophiolite complexes are located along the entire belt of ITSZ from Ladakh to southern Tibet. The ophiolitic mélangés are composed of an intercalation of flysch sediments and ophiolites of the Neotethys oceanic crust.

Jarhon Abbas



THE TETHYS HIMALAYA

The Tethys Himalaya is confined between the Tethyan Detachment Fault (TDF) in the south and the Indus Tsangpo Suture Zone (ITSZ) in the north. It comprises the Late Precambrian to Eocene marine sediments deposited in the Tethyan Sea. These sediments are largely unmetamorphosed and dominantly fossiliferous occurring in synclinal-type basins (Bagati, 1991).

THE GREATER HIMALAYA

The Greater or Higher Himalaya is limited by the Main Central Thrust (MCT) to its south and the Tethyan Detachment Fault (TDF) to its north. It comprises high grade Precambrian crystalline, Cambrian-Ordovician (500±50 Ma) granites/orthogneisses and the Tertiary leucogranites. The Greater Himalayan sequence shows progressive regional metamorphism ranging from green schist to upper amphibolites facies (Thakur, 1992). The granites frequently intrude the medium to high grade metamorphic sequences of metasedimentary rocks. The MCT, marking the southern boundary of the Greater Himalaya, is one of the most important tectonic elements associated with the Himalaya (hanging wall) in the north from the weakly metamorphosed rocks of the Lesser Himalaya (footwall) (Gansser, 1974; Valdiya, 1980).

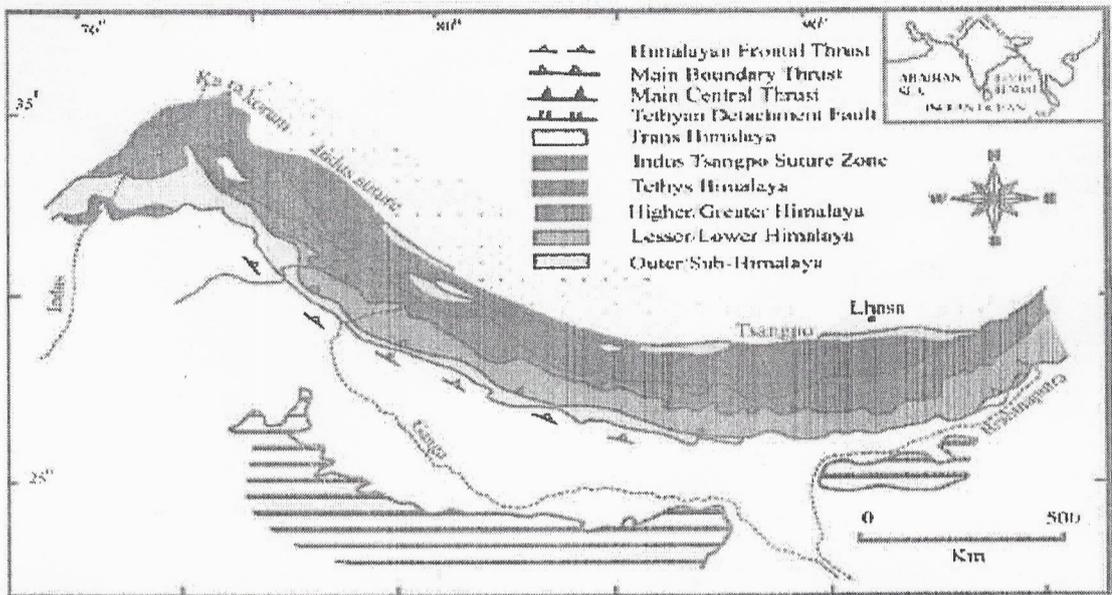


Figure 1: Lithotectonic Map of Himalaya (Valdiya, 1980)

THE LESSER HIMALAYA

The lesser or Lower Himalaya is limited by the Main Boundary Thrust (MBT), also designated as Main Boundary Fault (MBF) to its south and the MCT to its north and consists of the Late Proterozoic to Early Cambrian sediments intruded by some granites and acid Volcanics (Valdiya, 1980; Srikantia and Bhargava, 1982). It mainly comprises the marine sequences of Late Proterozoic to Early Cambrian age and some sedimentary record of transgressing shallow sea during Permian and Late Cretaceous to Early Eocene periods: The predominant rock types are quartzites, siltstone, shale and carbonates. There are zone of phyllite, schists, with subordinate impure marbles,

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metamorphosed mafic rocks, and augen orthogneisses (Valdiya, 1980). The MBT separates the northern Lesser Himalayan sediments (hanging wall) from the sediments of the Sub-Himalaya (footwall) to the south.

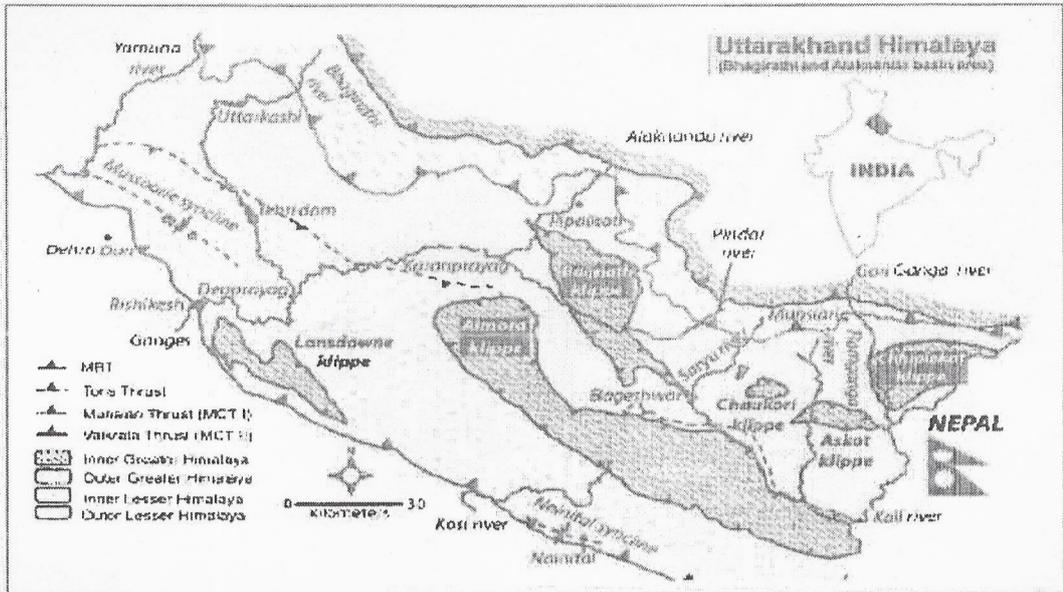


Figure 2: General Lithotectonic Setup of Alaknanda and Bhagirathi Basins of Uttarakhand (Celerier et al., 2009)

THE SUB-HIMALAYA

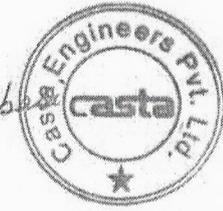
The Sub-Himalaya or Outer Himalaya forms low altitude foothills between the Himalayan Frontal Fault (HFF) to its south and the Main Boundary Thrust (MBT) to its north. It preserves the record of the post-collision sediments produced by weathering and erosion of the debris of the rising Himalayan front. These sediments were carried and deposited in the foreland basin, The Himalayan Foreland Basin (HFB). It consists of the Lower Tertiary sediments (Paleocene to early Miocene) comprising Subathu, Dagshai, and Kasauli formations which are marine to brackish water sediments and the Upper Tertiary sediments (Middle Miocene to Middle Pleistocene) consisting of the Siwalik Group fluvial deposits, along with the late orogenic intermontane deposits and alluvium. The HFF separates the Siwalik sediments in the north from the Indo-Gangetic sediments towards south.

GEOLOGICAL SET UP OF UTTARAKHAND HIMALAYA

The Uttarakhand Himalaya includes a 320 km stretch of the mountains between the Kali River forming the Indo-Nepal border in the east and the Tons-Pabar valleys forming the eastern border of Himachal Pradesh in the west. The geological framework of the area is rather complex. In the area, a large variety of rocks and rock complexes are developed in the central crystalline complex of Great Himalaya and the lesser as well as Sub-Himalaya. The area has witnessed granitic intrusions at different times, the oldest being 2500 Ma, followed successively by intrusions at 2200 – 2100 Ma, 1900 – 1600 Ma and 1100 Ma. The rocks show much lateral facies changes. Some of the rock complexes seen in one valley, are absent in the other valley. The terrain is very sensitive to mass wasting processes. It is therefore, important to understand the lithostratigraphy and structure of the

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Joshan Abbas



Uttarakhand Himalaya in the context of harnessing of water resources of the region for various hydropower projects on the Alaknanda and Bhagirathi basins.

LITHOSTRATIGRAPHY

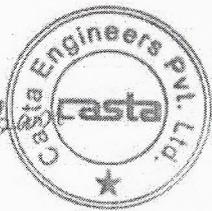
The geology of the area is very complex. Various workers have often given different names to the same rock succession in different areas. The following, general Stratigraphic succession as proposed by Kumar (2005), is given below in **Table 2**.

Table 2: Stratigraphy of rock succession in Uttarakhand giving various geological units and their lithological characteristics (modified after Kumar, 2005)

Granite (1100 Ma)		
(iii) Vaikrita Group (part) / Jaunsar Group	Undifferentiated Vaikrita/Mandhali-Chandpur-Nagthat formations	Purple, grey quartzite, grits and conglomerate, thin bedded limestone-phyllite/slate, laminated greenish grey phyllite/slate with lenticular greywacke, purple green quartzite, grit, conglomerate
(i) Garhwal Group	Granite (1900 Ma & 1600 Ma)	
	Berinag Formation	Quartzite with penecontemporaneous mafic volcanics
	-----Disconformity-----	
	Deoban Formation	Limestone-dolomite, shale
	Rautgara Formation	Quartzite with penecontemporaneous mafic volcanics
	Granite (2200-2100 Ma)	
	Uttarkashi Formation	Quartzite with penecontemporaneous mafic volcanic, dolomite-limestone, shale
(i) Central Crystalline Group	Granite (2500 Ma)	
	Badrinath Formation	Garnet, silliminite, muscovite, kyanite, bearing gneiss, mica, migmatite, calcsilicate
	Pandukeshwar Formation	Banded quartzite gneiss, para-amphibolites
	Joshimath Formation	Garnet-mica-schist, sillimanite-kyanite schist
	Bhimgora Formation	White quartzite
	Ragsi Formation	kyanite-mica schist, gneiss, para-amphibolites

Central Crystalline Group

It is exposed in the Greater Himalaya and occurs in a linear zone continuously in the Alaknanda Basin. They possibly form the oldest crystalline rocks of the Himalaya. The gneisses, migmatites, crystalline schist, thick quartzite with conspicuous horizons of calc silicates with psammite gneisses in the upper part form bulk of the metasediments. It is best exposed in the Alaknanda valley between Helang (south of Joshimath) and Badrinath and its southern contact with the Garhwal Group is a tectonic plane known as the Main Central Thrust (MCT).

Ragsi Formation

It is named after a prominent peak SW of Tungnath (between Alaknanda and Mandakini valleys) and described as the Ragsi schist and gneiss Member of the Tungnath formation. In Nagol Gad, it is in contact with the Garwal Group along Main Central Thrust (MCT), and is overlain by the Bhimgora Quartzite. In the Alaknanda valley, along Helong it is associated with para-amphibolite/marble and gneisses. It continues westwards to the Mandakini valley and is represented by quartzo-feldspathic schist and gneiss, kyanite-staurolite schist and cummingtonite-hornblende schist. In the Pinder River, the Ragsi Formation along with overlying Bhimgora Quartzite is cut-off by the MCT.

Bhimgora Formation

White coloured, fine grained recrystallized quartzite with abundant sericite flakes makes the Bhimgora Quartzite. It is named after Bhimgora Chatti along the Chamoli-Okhimath road. It is traceable from Bhimgora in the Nagol Gad to north of Helang in the Alaknanda valley, associated with it is chlorite phyllite which is possibly derived from amphibolites. In the Mandakini valley, it is exposed as a thin band north of Kalimath and continues westwards to south of Sonprayag and beyond.

Joshimath Formation

Joshimath Formation comprises, regionally metamorphosed banded psammitic and pelitic sediments represented by interbedded sequence garnet mica schist, staurolite kyanite schist, sericite quartzite, quartz porphyry, amphibolite and associated coarse-grained biotite augen-gneiss. These rocks continue westwards and have been mapped as the Chandersila Schist of the Tungnath Formation. Okhimath Formation outcropping between Okhimath and Lanka in the Mandakini valley. Vakdiya (1980a), however, considered the latter contact to be a tectonic plane referred to as the Vaikrita Thrust.

Pandukeshwar Formation

The psammitic series of the Alaknanda at Pandukeshwar consists of regularly bedded quartzites/banded quartzitic gneisses in which sedimentary structures such as cross bedding are preserved. Interbedded with quartzitic gneisses is garnet-biotite schist.

Badrinath Formation

It is well exposed between Hanuman Chatti and Badrinath in the Alaknanda valley. It consists of garnet, sillimanite, muscovite and kyanite-bearing gneiss, mica schist, migmatites, calc-silicates, and garnet amphibolites intruded by leucogranite and pegmatite. In Dhauliganga, the Badrinath Formation is well exposed around Kosa where they are associated with quartzitic gneisses.

ENGINEERING GEOLOGICAL DESCRIPTION OF THE ROAD ALIGNMENT

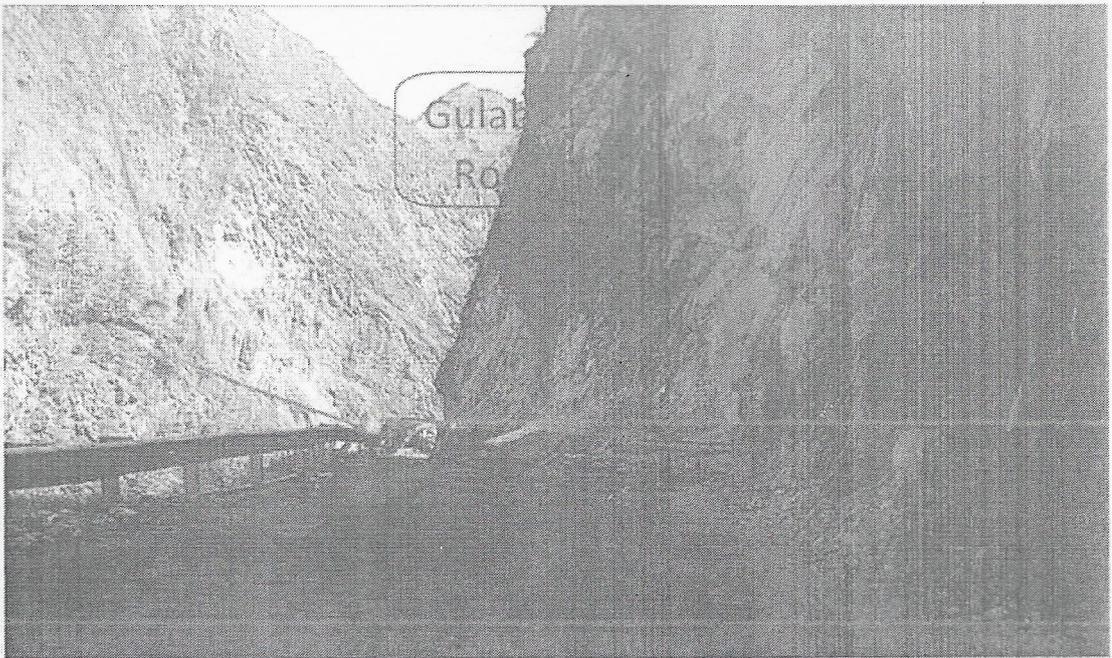
The main engineering geological characteristics of the landslide are described below in some detail.

A. GULABKOTHI

This is a rock fall zone.

Jashan Abbot





B. HELANG

Landslide causes

1. Heavy precipitation in June 2013 causes the saturation of debris mass and zone of weakness formed at the interface debris mass and joint plane of in-situ rock.
2. The upslope comprising soil and debris material which appears to be saturated and water is percolating down.
3. The road constructed on filled material and provided heavy concrete wall as retaining structure in steps, resting over on debris material, hence, overloading the slope.
4. Due to saturation, mica schist bands acted as a lubricant for sliding down along weak planes.

Landslide process

It is an old debris slide and translational movement of debris mass below the road is observed and in turn road is sinking. Heavy precipitation and continuous Percolation of water causes the saturation of debris mass and zone of weakness formed at the interface debris mass and joint plane of in-situ rock. The upslope area is comprises of soil and debris material of old slide is saturated and water percolating through it. The heavy concrete wall has been provided in five steps and it has been rested on debris material which appears overloading of slope.

Slide Type

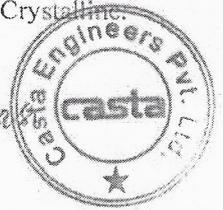
Type of material involved Debris material comprising of huge blocks of banded gneiss and mica schist above the road and angular, unsorted rock fragment of quartzite, gneiss in silty, Sandy matrix

1. Type of movement Sinking Zone and translational
2. Type of slide Debris slide and sinking zone
3. Rate of movement/activity Rapid in debris fall and slow in sinking
4. History of slide Old slide reactivated after heavy rainfall between 16th & 17th June 2013.

Geological details

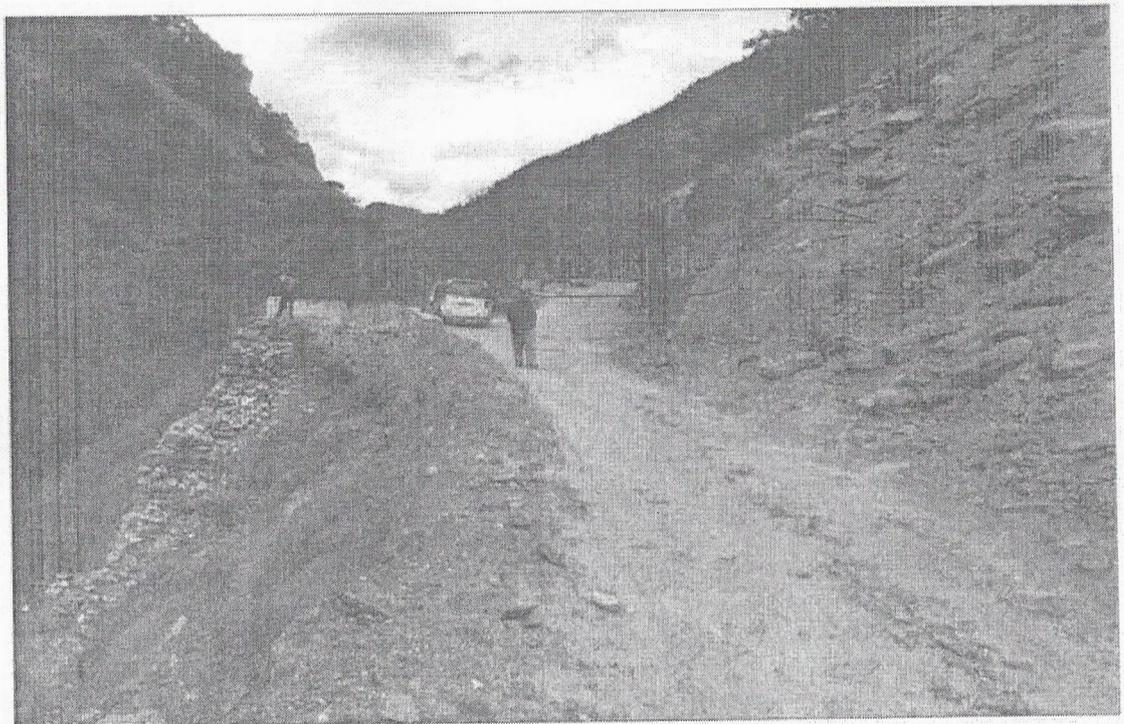
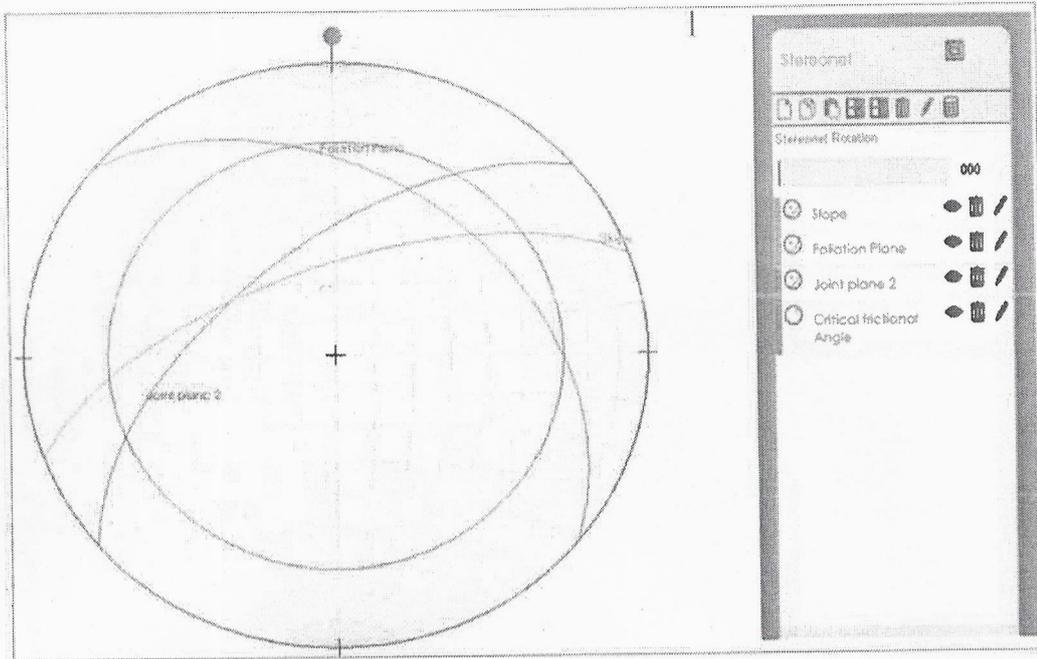
- i. Lithology
- ii. Slope forming material Sheared gneiss with mica schist bands of Central Crystalline.

Jashan Abasi



Rock exposed is sheared gneiss with bands of mica schist. Rock slide with angular blocks of gneiss with mica schist. Rock fragments size varying size and maximum up to 4 m (L) X 3 m (W). 20 Structural details J1: $40^{\circ}/N040^{\circ}$ (Fol.), J2= $60^{\circ}/N320^{\circ}$ forming wedge with J1.

Stereo plot



Jashar Abbas



C. GOVINDGHAT-II

Govindghat is a town in Chamoli district, Uttarakhand, India, located at the confluence of the Alaknanda and Lakshman Ganga rivers. It lies around roughly 22 kilometers (14 mi) from Joshimath on NH58 at an altitude of 6,000 feet (1,800 meters).

The surface geological studies of Govindghat location 2 reveal that Type of material involved Debris comprising of unsorted and unconsolidated fluvio-glacial cone/fan deposit comprising blocks of quartzite, gneiss in a sandy matrix. Max. Block size observed is of 5m diameter and angular. In the history of Govindghat location 2, it is the first time that much slide happened. The type of movement is Debris fall and flow, the type of slide is Debris slide and the rate of movement/activity is Rapid.

Geomorphology and Hydro-geological structure with old debris cone, steep upslope and down slope, gully formation. The Land use/cover is wet and moderately vegetated forest land.

Landslide process:

Due to heavy precipitation for 3-4 days, toe cutting by Alaknanda river, saturation of the overburden mass leading to reduction in shear strength. Due to heavy and continuous rainfall in the Alaknanda valley, the swollen river has eroded the toe of the slope.

Due to landslide the Communication network Wash out of road of about 150 m but there is no loss of human life and the building /infrastructure.

Slide morphology

Length = 60 m

Width = 150 m

Area = 7,000 sq. m.

Height = 50 m

Volume = 77,000 cu. m.

Depth = 15 m

Run out (distance, zone, hazard) ROD = 120 m.

Slope/angle & direction $75^{\circ}/N080^{\circ}$



Jarman Akbar



D. GOVINDGHAT-III

Govindghat is a town in Chamoli district, Uttarakhand, India, located at the confluence of the Alaknanda and Lakshman Ganga rivers. It lies around roughly 22 kilometers (14 mi) from Joshimath on NH-58 at an altitude of 6,000 feet (1,800 meters).

The surface geological studies of Govindghat location 3 reveal that Type of material involved Debris comprising of rock fragments of quartzite and gneiss (few cm to 3-4 m) embedded in silty matrix. In the history of Govindghat location 2, it is the first time that much slide happened. The type of movement is Debris fall and flow, the type of slide is Debris slide and the rate of movement/activity is Rapid.

Geomorphology and Hydro-geological structure with old debris cone, steep upslope and down slope, gully formation. The Land use/cover is wet and thickly vegetated forest land.

Landslide process:

Due to heavy precipitation for 3-4 days, toe cutting by Alaknanda River, saturation of the overburden mass leading to reduction in shear strength. Due to heavy and continuous rainfall in the Alaknanda valley, the swollen river has eroded the toe of the slope.

Due to landslide the Communication network Wash out of road of about 90 m but there is no loss of human life and the building /infrastructure.

Slide morphology:

Length = 150 m
Width = 90 m
Area = 11,500 sq. m.
Height = 115 m
Volume = 80,500 cu. m.
Depth = 10-15 m
Run out (distance, zone, hazard) ROD = 150 m.
Slope/angle & direction 55°/N040°

Structural details:

J1: 35°/N025° (Fol.) J2=65°/N100°, RP, cont. 2-3 m;
J3=60°/N170°, RU, Sp. 2-5 m



Jashan Abbot

