

# Mass movement problems along Prithvi Highway, Nepal

by

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## Abstract

Because of adverse topographic conditions and poor economic status, Nepal is still suffering from lack of road network all over the country. Out of the 15 major highways, only two highways connect the Kathmandu valley from rest of the country. Among them Prithvi highway is the important one. However, bad alignment, bad topographical and geological condition and faulty construction and maintenance technology make this highway very prone to landslides and other mass movement problems causing much woe since many years.

Some parts of this highway are used to block due to mass movements and threaten the traffic during monsoon every year. This report deals some major mass movement problems along this highway and is primarily based on the field visit along the Prithvi highway, Nepal.

*Keywords* : Mass movement, Landslide, Prithvi highway, Topography, Geology

## 1. Introduction

Rugged and fragile geophysical structure, steep topography, concentrated precipitation, unplanned infrastructure and settlement, dense and increasing population, poor economic condition and low literacy rate have made the Kingdom of Nepal prone to the natural disasters. Every year, many people loss their invaluable lives due to these natural disasters. A recent data showed that in this year until September, 187 people were killed and 37 were injured in 67 different mass movement events occurred all over the country. Moreover, 105 houses were completely destroyed and 140 houses were partially damaged. In addition, many important highways were blocked due to series of mass movements occurred during this year's monsoon (June-September). Being interested in the study of occurrence of mass movement phenomena, especially along the highways, authors have visited Nepal. The authors have inspected several projects related to mass movement problems along some major highways with Japanese and Nepalese landslide experts. In addition, the authors have also inspected Prithvi highway and have collected soil samples of slope failure sites. Besides, the authors have also gathered some secondary data related to this highway from several Government offices of Nepal. This report is primarily based on the field visit of Prithvi highway and the available collected data.

## 2. Importance of Road and their Development in Nepal

Transportation plays significant role for the economic development of any nation. For the mountainous and landlocked country, like Nepal, where the possibility of navigation is limited

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and rail network is only 51km, the importance of road network is very high. It is said that, Nepal conducts more than 71% of its international trade through the surface transportation. Consequently, the Government of Nepal has given top priority in this sector since many years.

Actually, the systematic development of road network began in Nepal only after the First Five-Year Plan (1956). Prior to the First Five-Year Plan, Nepal had approximately 600km of road all over the country. Since then the road length has increased enormously. By the end of March 2001,

Nepal has 15,458km of road network all over the country. But this much length of road network is not sufficient for the development of this tiny nation. The Kingdom is still lacking in road network development all over the country. 30% of the people who live in hills and mountainous areas do not have access to road even today. The mountainous terrain presents great challenge for the construction and maintenance of highways throughout the Kingdom.

One of the most important national highway, East-West highway, runs along the low land of Terai in the southern part of Nepal which connects the eastern part of Nepal with the western part. This main highway links the capital city Kathmandu by two routes (1) by Tribhuvan highway, (2) by Prithvi highway through Mugling. Besides that there are limited numbers of North-South routes, which link the East-West highway. Among, the two highways which connects the capital city Kathmandu, Prithvi highway is the important one because Tribhuvan highway has very narrow lane, tortuous bends, steep gradients and above all, runs up to the height of 2100m above mean sea level. The journey through this highway is very tough. Most of the people do not want to travel through this highway. Therefore this highway bears negligible traffic volume these days (Fig.1).

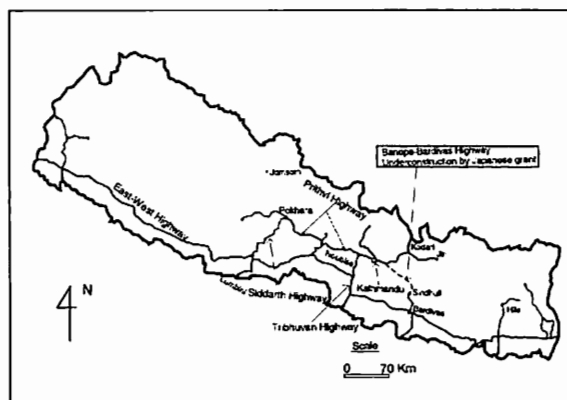


Fig. 1 : Schematic map of Nepal showing Important highways.

### 3. Background and Importance of Prithvi Highway

Prithvi highway is a 175km long road that runs from Noubise to Pokhara. If we consider the 25km length from Kathmandu to Noubise, then the total length of this highway becomes 200km. It is a double lane valley road primarily constructed in cut sections along the Mahabharat range and high mountains through most of the alignment. The radius of the road is varying from sharp bends at a difficult terrain to smooth curves at easy sections. The gradient is smooth throughout the whole stretch. It was constructed under the Chinese grant assistance program me during 1966-1974. Then after, it became the arterial road to connect Kathmandu with western part. After the construction of Mugling- Narayanghat sector (36km), this highway became the main link to connect the eastern part too. However, due to bad alignment, bad topographical and geological condition and faulty construction technology, this Highway is suffering from bank erosion, bridge wash outs, debris flow and other severe mass movement problems since many years.

This highway has two sectors. In the first stretch of 100km up to Mugling, it runs

along the bank of Trishuli River through most of its alignment. It passes through 20 major thrust/fault lines even within 100km from Kathmandu. So, this stretch of the road is highly vulnerable to mass movements and there is no alternatives except the painful Tribhuvan highway. The second stretch of this highway runs along the Marsyangdi River and it is less vulnerable compared to the former. It has other alternatives also.

Limestone, Slate, Marble, Schist and phyllites are the main dominant rocks along the alignment. Only in Jogimara about 90km from Kathmandu, at least 10 passenger buses have been hit by the moved mass to the river since 1980, killing hundreds of people. The 1993 flood and landslide have washed out three major bridges (Agra Kola, Belkhu khola and Malekhu khola) of this highway paralyzing the life in Kathmandu valley with food and materials shortage. The traffic could not be run for about one month. Since then, this highway is generally stopped by landslide and mass movement every year at least for a couple of days.

Due to over traffic and bad surface condition, improvement had been done in this road along with widening in 1990's with the support of Asian Development Bank. Although half of the total highway alignment had been completely widened and improved, disaster of 1993 has damaged the road severely in many places, washed out many bridges, culverts and pavements.

At present the condition of the road is very good except near the mass movement areas. The importance of this highway is understood by the fact that about 80% of traffic flows to the Kathmandu valley through this highway. When the traffic is interrupted in this highway due to landslide or some other reasons, people of Kathmandu have to stand in long queues for daily necessity items such as petrol, kerosene, cooking gas, sugar etc.

#### **4. Some major Landslides along the Prithvi Highway**

Many mass movements have been occurred every year along the Prithvi highway. Some of them are very big and of permanent nature. At least 62 landslides of various degrees have hit this mid-hill highway during this monsoon. The most famous one is the landslide at Krishnabhir, which had alone occurred for 18 times. This clarifies the condition of this road. Some of the major landslides along this highway are listed below.

##### **4.1 Krishanabhir Landslide**

This massive landslide is located around 78km from Kathmandu towards Pokhara. It was first occurred on August 11, 2000 blocking the traffic for 11 days. The debris buried the road up to 10m height and excess of which had flown down to the river. The fallen rocks and soil impeded the river's water flow for almost fifteen minutes forcing the people of near by village to escape from the area at night. This year also it stopped the traffic twice for a couple of days and the department of road had to have great effort to open this road. At present this landslide seems stable. All the debris have been removed and thrown to the Trishuli River and huge gabion wall has been constructed to check the further debris flow.

The total width and height of this landslide were 200m and 220m respectively from road level and average gradient was 35 degrees on August 15, 2001. The total volume produced by this landslide was estimated about 380,000m<sup>3</sup>. It is said that all the debris fallen into the Trishuli River had been washed away by its current (Photos 1, 2).

##### **Geology and landform**

The area is composed of gray argillaceous slate and phyllite of upper Nuwakot formation of Paleozoic era. As per the experts of Nippon koei Co., the collapsed landslide was a part of huge rock type landslide, which was located behind the collapsed landslide.



Photo 1 : View of Krishanabhir Landslide from Pokhara side.



Photo 2 : View of the condition of road at Krishanabhir on September 22, 2001. Notice the preventive work is going on to check the debris flow.

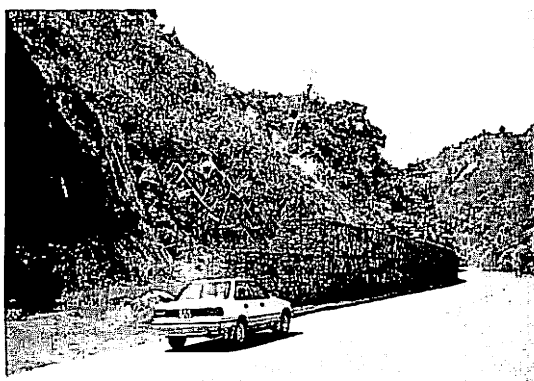


Photo 3 : View of the present situation of Jogimara Landslide and the road. Notice the massive control work.



Photo 4 : View of Nagdhunga Landslide from Kathmandu side and the condition of Road on September 21, 2001.



Photo 5 : View of the Road at Nagdhunga Landslide site. Notice the damage on the Composite Retaining Wall below Road.

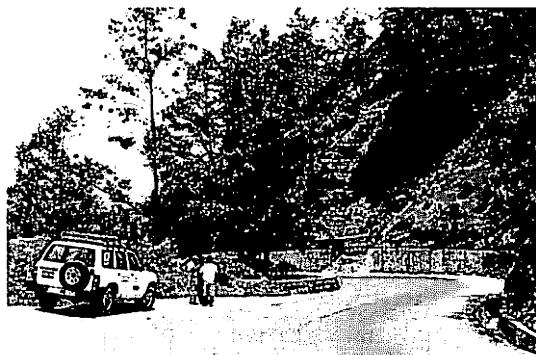


Photo 6 : View of the landslide Control Work at Nagdhunga, 12.0km west from Kathmandu.

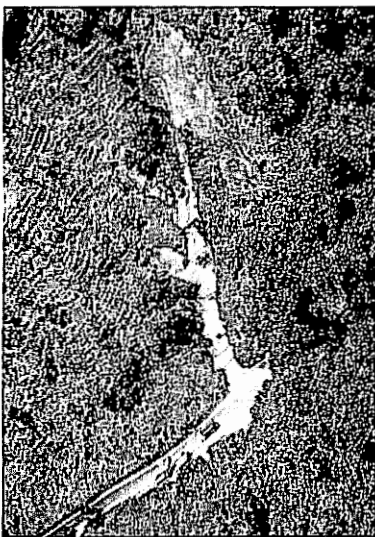


Photo 7 : View from top landslide and its control Work at Nagdhunga 15.0km west from Kathmandu.



Photo 8 : Close View of Landslide near Dahaki Khola.

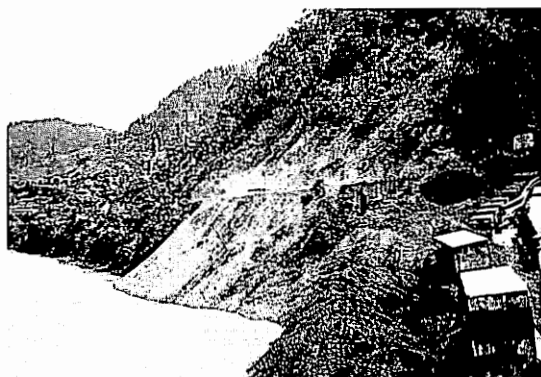


Photo 9 : View of Landslide near Dahaki Khola from Pokhara Side where the Road settle due to the bank erosion.



Photo 10 : Sign of Danger kept by the Department of Road (DOR), the only authority who construct and take care of Road in Nepal, stating that drive slowly, the Road has damaged (settled).



Photo 11 : View of bank erosion at opposite side of the Highway

#### **4.2 Jogimara Landslide**

The Jogimara landslide, located at the slope close to the old limestone quarry, has been remained a most hazardous landslide between 80's to 90's along the Prithvi highway. It has carried several buses and trucks into the Trishuli River and hundreds of people lost their lives. The slide lies on Benighat slates and Jhikhu bands. The geology of area consists of limestone, black schists and slate. The rocks are extremely jointed and the joints spacing vary from a few centimeters to tens of centimeters in the slate and from tens of centimeters to a few meters in the limestone. At the time of massive landslide in 1993, the natural slope of this landslide was found 40 degrees to vertical and the collapsed slope was 30 degree. The length, breadth and depth were found about 70m, 80m, and 15m respectively.

At present the Jogimara landslide is under control. The department of road HMG/N has excavated the great amount of weathered materials and constructed the massive gabion walls at landslide area (Photo 3).

#### **4.3 Nagdhunga Landslide (Kathmandu-Noubise sector)**

This landslide located at about 12.5km west from Kathmandu has occurred on September 9, 2001 and blocked the busy traffic for couple of hours (Photos 4, 5).

There are other two landslides, located near this landslide at 12.0km and 15km from Kathmandu where protection and stabilization works has been recently completed by department of water induced disaster prevention (Photos 6, 7).

#### **4.4 Landslide near Dahaki Khola**

This landslide has occurred in August, this year. Part of Prithvi highway had been washed off, when about 100m of road sank near Dahaki Khola. In addition, landslides occurred at the hillside blocked the highway for a couple of days. Currently vehicles are moving above the deposited debris (Photos 8, 9, 10).

Aforesaid are the major landslides along the Prithvi highway. Some of them are fresh and have occurred this year during monsoon. Besides, there were about 44 large and small landslides found during our field visit along that highway up to Mugling. This brings forth the vulnerability of this highway. Every year new landslides are developed and the older one becomes more and more dangerous. As this road is running along the side of the river, bank erosion is also frequently occurred. The most vulnerable areas along this highway up to Mugling are around Jogimara, near Bishal Tar, Malekhu, in the vicinity of Belkhu, Galchi, Mahadevbesi, Noubise, Kurintar etc (Photo 11).

### **5. Causes of Mass Movement along Prithvi Highway**

Most of the mass movements along the Prithvi highway are induced due to adverse topography and poor geological condition of the alignment alongwith concentrated precipitation, acting as a catalyst. Moreover, these causes are highly enhanced by anthropogenic activities also. The main causes of excessive mass movements along the Prithvi highway has been explained below.

1. **Fragile geology and bad alignment :** This highway runs along the bank of Trishuli and Marsyangdi River through most of its alignment. Moreover, this highway crosses 20 major thrust/faults lines even within 100km from Kathmandu. The highway crosses Main Boundary Thrust at around Belkhu area. Limestone, Slate, Marble, Schist and Phyllites are main dominant rocks along the alignment. These rocks are very weak in nature. In many places joints and faults are prevailing. The ground water percolates through these joints and faults and

considerably increases the pore water pressure, leading to debris and rockslide. Also during our inspection, we noticed so many big trees whose roots spread deep on the sloppy land. The spreading of roots further widens the faults and joints of the fractured rock. The crack increases more and the rock becomes loose and ultimately fails when the wind swings the tree to and fro.

2. Intensive Precipitation : The concentrated intensive precipitation is another important factor that leads the excessive mass movement along this highway. Mass movement always occurs in this highway during the rainy season. In several areas, the highway is very close to the river. In such areas the river scours the base and toe erosion is also inevitable. The example is Dahaki Khola landslide, where part of the highway had been washed away by the river. In 1993, because of heavy rainfall various part of this highway was damaged and the cost of the damage was estimated to be about 572 million rupees.
3. Faulty construction/maintenance technique : We know that the mountain environment is very sensitive to the natural and man-made processes. When we build any structure on it without understanding of the impacts to and from the structure, it will definitely create problem for itself and the environment. That is happened in this road also. During construction and maintenance phase, the technicians did uncontrolled blasting without considering the rock type, degree of jointing, fracturing and joint spacing. That triggered the massive hill instabilities along the road. During our field visit, we noticed that the present series of

landslides are the results these blasting activities carried out during the construction and maintenance of the highway.

4. Anthropogenic Activities : Anthropogenic activities include deforestation, improper land use, unplanned infrastructure development, extraction of sand, gravel and boulder from the riverbed, unmanaged quarrying etc. along the highway.

We found several cultivated lands on the steep slope along this highway, during our inspection. Besides, unlined irrigation channels are also seen on the steep slope

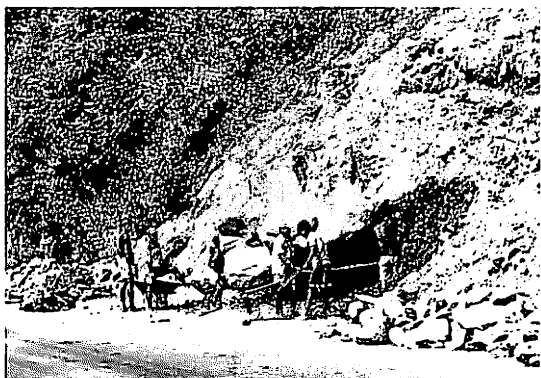


Photo 12 : View of Roadside quarrying work along Prithvi Highway.

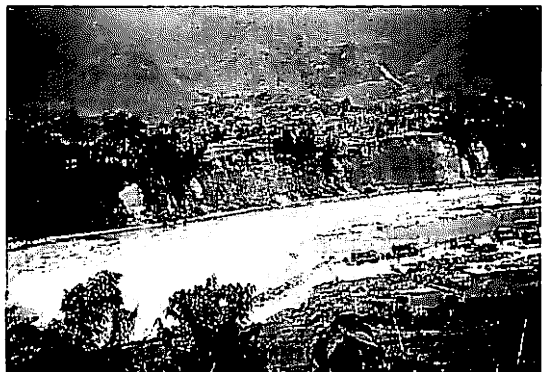


Photo 13 : View of River bank erosion and extraction of sand and other materials along the River channel.



Photo 14 : View of landslide along Prithvi Highway threatening the adjacent houses.

at some parts of this highway, which has made the slope more vulnerable. People used to graze their cattle on the hillside also. We also noticed quarry sites both on hillside and valley side. Though mining activities less than 50meters from the highway is banned in Nepal, we found that several people were quarrying out limestone from the slopes, which have further aggravated the fragile condition of roads. The worst thing that we found was that people were extracting out sand, gravel and boulder along the steep channel of the riverbed. It increases the vulnerability to the riverbank and bridge foundation (Photos 12, 13, 14).

## 6. Conclusion

Roads are no doubt prime structures for the economic development. But the series of successive failures of roads all over the country and the huge amount of money spent so far for the maintenance of these roads have aroused serious questions on the technology of construction in Nepal. This demands the multidisciplinary approach from social, economic, engineering, environmental and bio-technical considerations besides engineering-geological inputs for the construction of highways in hilly and mountainous areas of Nepal.

Though Government has made environmental impact assessment study mandatory prior to the construction of roads, the roads are being built in haphazard manner in the quest for economic development and the results are dire-periodic landslides with the break of monsoon.

Realizing its importance as well as vulnerability, the hazard mapping of Prithvi highway is necessary. This will be helpful for the Government to allocate the necessary budget to prevent various mass movements in the future according to their risk potential along the highway. In addition, systematic monitoring can be done for existing big landslides and appropriate countermeasures can be applied within available budget range. Moreover, the Department of Road, with its limited number of heavy equipments like bull dozers and loaders, can be able to prioritize the location of such heavy equipments during monsoon.

In this regard, the author's research work on landslides along Krishanabhir-Kurintar sector of Prithvi Highway will be very helpful in future.

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