

## Road Construction, Maintenance Challenges and their Solutions in Kashmir

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### Abstract

The primary focus of our study is to identify the challenges and difficulties that we face and to find some feasible solutions while constructing and maintenance of roads in the state of Jammu and Kashmir. The roads pass through the swathes, that are mostly frost prone, located at high altitudes and we experience sub-zero temperature there. Apart from its mountainous nature, the climatic conditions are very harsh for most part of the year, in which the precipitation is more, mostly in the form of snow that covers the whole of the land including roads. The valley has a few exits in the form of national highways that pass through mountainous ranges at very high altitudes, where the snowfall is heavy during winter months. The state being dominated by undulating topography, road is the prime means of transport. The carving of roads and their maintenance through the continuous mountainous ranges has become a challenge for the engineers and constructors. The cause of concern is that Kashmir has the road density of 35.71 km per 100 sq km, this is one of the lowest in the country. In this paper, we introduce some of the materials and some of the improved methods in road construction in order to overcome the challenges that we encounter during construction and maintenance of roads in Kashmir.

**Keywords:** Roads; Frost; Construction; Landslides; Snow; Shear strength; Rocks

### Introduction

A lot of work has been done to identify construction and maintenance challenges in cold and hilly areas. The data were arranged about how to prevent the roads from frosting and securing road constructions [1]. The information regarding the formation, checking and prevention of frost formation due to surface and sub-surface water [2]. The method of construction and the error in panning and designing of Road leads to the frost formation [3]. On the basis of various previous researches, a strategy was developed to prevent formation of frost [4]. Seven techniques were developed to reduce the frost formation [5]. The cut off drains should be provided to prevent water from reaching the roads [6]. The number of landslides in a particular area depends upon its distance from epicentre, the gradient of slope which is explicitly related to shear strength and the soil type. Increase in the intensity of earthquake magnitude causes upsurge in the number of landslides [7]. The cause of landslides due to earthquakes is the reduction in slope stability due to continuous shaking [8-9]. The landslides occur when the shear force overcomes the shear strength of the interface leading to instability of the slope that causes the displacement of soil particles and finally the mass movement [10]. The studies were done on the pavements that were inundated due to floods [11-14]. The pavements loose its strength quickly for first six to eight weeks and then steadily contrary to the predicted design [12,13].

### Geographical features of Kashmir valley

The state of Jammu and Kashmir has been declared as mountainous state by "Department of Geological survey of India". Kashmir is a valley, surrounded by mighty mountains on all its sides. The main Kashmir Valley [34.1667° N, 74.7500° E] running 132 km long and 32 km wide covers the area of 15,520.3 km<sup>2</sup> with the elevation of 6,070 ft above sea-level. The climate remains cold for most part of the year mainly from November to march that experiences maximum snowfall. The annual rainfall is 1530 mm and the average snowfall is 195 cm. The recorded high temperature is 33°C and the recorded low is -18°C. The valley of Kashmir lies in zone 4 and zone 5 of earthquake zoning as per "Department of geological survey of India". These zones are considered to be the earthquake prone zones. The interior roads are

prone to flooding while most of our major roads pass through high altitudes of Pir-panjal mountainous ranges, especially the main exits of valley like Jammu-Srinagar national highway that passes through Patnitop at an altitude of 6640 ft, Mughal Road that passes through Pir ki Gali at an elevation of 11500 ft and the Anantnag-kishtwar road that passes through sinthan top at the altitude of 12500 ft from mean sea level roads are exposed to very harsh climatic conditions like heavy snowfall and intermittent rains. These conditions lead to various defects of soils, rocks, slopes through which the road passes the ultimately leads to weathering, reduction in shear strength of soil, instability of slopes besides various road defects of roads. Thus, we face a lot of challenges which constructing and maintaining roads in these areas [15] (Figure 1).

### Challenges

#### Floods

The internal roads connecting various districts within the Kashmir valley are both hilly roads as well as plain roads. The roads situated in plain area including the National highway that divides Kashmir into two parts stretching from north of Kashmir valley to the extreme south, is the road of strategic importance [16]. This road lags drainage system and is more prone to flooding, because it moves parallel to the river Jhelum. whenever there are heavy rains during summers, it receives large quantity of water from its catchment area including various tributaries like Lidder, vaisho, sind etc and it overflows, it inundates the national highway viz, NH-1A and all the major district and village roads that comes in its way right from south of the valley up to north

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Figure 1: The map of Jammu and Kashmir (study area).

end [17]. There is no flood channel present to drain away the water, although there was one channel constructed in the Srinagar city but that does not exist anywhere now due to encroachments and solid waste disposal there. The recent flood of 2014 obstructed the widening process of national highway due to inundation of the whole area. Now the government has taken some initiative to construct flood channel from Awantipora the will take extra discharge from the river and will pour the into the Wulur lake. Due to this, a lot of large stretch of national highway will be prevented from inundation. Some low-lying roads remain submerged for a long time, due to that; they develop the various defects like potholes, settlement of subgrade and stripping of bitumen. The area surrounding river Jhelum has a soil that remains mostly saturated and thus retains more water. Since the area has mainly the flexible pavements, a lot of settlements occur there even at lesser loads [18]. There is not much impact on the rigid and semi-rigid pavements, although there may be refecton cracking due to differential settlements in the subgrade. Thus flood mainly affects the pavement and hinders the construction work (Figures 2 and 3).

### Ground frost

In the hilly areas of Kashmir, the temperature goes below  $-15^{\circ}\text{C}$  in winters and never exceeds  $15^{\circ}\text{C}$  even in the summer months of June and July. In winter months, these roads remain covered by snow and the frost action takes place. The sediments of glacial and glaciolacustrine origin are more frost sensitive. Frost depth is dependent on the annual frost sum the grain size of the soil, and snow depth. The capillarity of soil is much more affected by its frost sensitivity. The capillary rise of water can be up to 3 m in silty soils. Due to capillary rise of water to the surface, it freezes and forms segregated ice layers. The sediments retain water on the surface and form frost heaves that is the main concern for road constructors (Figure 4).

The frozen ground is considered to be the stabilized soil and it can't create any problem unless it remains frozen. As the day temperature



Figure 2: Road cracking because of floods.



Figure 3: Vehicle passing through inundated roads.

increases, thaw starts and its carrying capacity is lost. Frost thaws first at the center of the road and forms a groove-like frost table in the road embankment, which delays the drainage of melt waters. Due to this, the water moves along the road surface instead of the drainage system constructed, resulting in the formation of longitudinal cracks on the embankment sides. The uneven frost heaving causes the deterioration of pavement, longitudinal and transverse cracks and potholes. If ground

frost remains for longer period, it will lead to accidents due to slippery conditions on the roads (Figure 5).

### Snow drift

The whole Kashmir remains under snow cover for most part of the year and the major places prone to snow storm includes Banihal top and Patnitop on national highway, Sinthan top on Anantnag-Kishtwar road and Peer ki Gali on Mughal Road. The frost so formed and the continuous freezing and thawing action, deteriorates the wearing course and it scraps off the upper layer of the road when we try to clear the frost off the roads (Figures 6 and 7).

To predict snow accumulation in different environment, Finnish engineers have used a Russian formula

$$Q=Lh_m\Phi\eta\beta$$



Figure 4: Vehicle passing through frozen road.



Figure 5: A view of frozen road.



Figure 6: Vehicle passing through snow-bound road.



Figure 7: Deteriorated condition of road due to heavy snow fall.

Where  $Q$ =the depth of snow on one meter wide strip;

$L$ =the length for which snow accumulates;

$h_m$ =maximum snow depth in 10-year period;

$\Phi$ =erosion threshold value for the wind speed 5 to 7 m/s in different environments: 0–0.1 steep, vegetated landscape;

$B$ =sublimation coefficient of snow, normally 0.7;

$\eta$ =coefficient of the steadiness of the wind drift from different directions.

The length for which snow accumulates as follows:

- 15,000–20,000 good topography or icy surface
- 12,000–17,000 open hilly area
- 3000–6000 hilly area, some vegetation
- <500 steep slopes, vegetated
- <600 forest

Maximum snow depth in 10 year period (higher values are used with wind speed) 5 m/s;

Erosion threshold values are as follows:

- 0.2–0.3 hilly tundra, scattered vegetation
- 0.4–0.5 open, hilly place
- 0.7–0.8 open, even place
- 0.7–0.9 open, frozen surface
- 0.8–1.0 mountainous summit

### Earthquakes and landslides

The Kashmir valley lies in the zone 5 of earthquake zoning, which is considered to be the earthquake prone zone, we often experience big earthquakes causing the loosening of soil and ultimately the huge mass movement of earth. The Srinagar-Jammu national highway passes through these Himalayan ranges that are prone to landslides. The Himalayas were formed some 26 million years ago, and even today it is not in stable condition. The mass slides rose so quickly that even today its slopes are in unstable condition. There are heavy rains and snow during winter months because of high RL of this place that has resulted in deep weathering profiles, on slopes that are hardly stable. This accumulation of water in soil molecules develops pressure that



leads to the shear failure of the soil and thus the mass movement of the soil. These landslides and snow avalanches rolling along the hill slope at very high speed destroy the roads located beneath the hill. The landslides these days have become a norm now rather than exception, even a little downpour leads to the landslides and hence the closure of the highways (Figure 8).

The part of national highways from Banihal to Ramban including Penthall, Digdol, Ramsu etc. are more prone to landslides because they consist of sedimentary rocks. These rocks vary in thickness from 0.5 m to 3 m but normally it is 1 m. Apart from this, various sandstone beds exist. These rocks are porous and highly permeable because they have been faulted to produce small broken rock masses. Water penetrates deep into its surface and cause weathering zones and develops pressure and lubrication in failure planes. Thus the rocks lose their strength. The lower Himalayas are made up of Meta morphic rocks that are intensely folded and fractured and are hence more prone to weathering (Figure 9).

### Drainage problems

These roads passing through hills need more care as far as drainage is concerned. There are no “catch water drains” to divert and intercept the water from the hill slope. Whenever it rains, there is massive mass-movement of earth, the debris of landslides and the accumulated snow block the drainages along the roadside. The accumulated snow along the roadsides melt steadily when the days become hotter and hence become a menace for its maintenance. Maximum length of roads in

Kashmir run through the bottom of the hillsides due to which, the rainwater from the slopes rundown and cause deterioration of pavement of surface. The accumulation of water leads to the undulations due to differential settlements that is caused due to the retention of moisture in the subgrade soil. This problem mostly prevails in the road stretches which is surrounded by the two hills where no sunlight reaches (Figures 10 and 11).

### Material transportation issues

The special attention and treatment for roadway construction in extremely cold weather conditions starts from mobilization of resources. Carrying pavement construction materials to such a high altitude is very difficult where the temperature is very low and can be very uneconomical. It is difficult to maintain the high temperature of bitumen that is essential for the success and long life of any pavement. Apart from this, working in sub-zero temperature can lead to the deterioration of health, productivity and workmanship of workers, masons and engineers working at the site. The main diseases associated with cold weather working are Frostbite and Hypothermia. In Frostbite there occurs the actual freezing of tissue. Exposed skin becomes vulnerable to frostbite when the air is cold. Hypothermia occurs when the body core temperature drops below 35°C. Once this happens the body loses its ability to prevent heat loss and is losing heat more quickly than it can create heat. The machinery planted at the site face the problems like freezing of fuels and lubricants. Thus reduces the efficiency of machines.

### High initial construction and maintenance costs

At the initial stage, in hilly areas, the road construction costs very



**Figure 8:** Road closure due to landslides.



**Figure 9:** Clearance of debris from the road.



**Figure 10:** Deteriorated drainage system.



**Figure 11:** Drainage failure causes water-logging.

much. This is because of heavy earthwork and blasting of hard rocks that is to be done. It is time-consuming process and takes years to complete the project. The four-laning of the highway was started in 2015 and missed its first deadline and now its deadline has been set as 2019. The amount of 2136.97 crore has been sanctioned for the Udhampur-Ramban sector and 2168.66 cr. was approved for the Ramban-Banihal sector. It misses many of the deadlines because of inclement weather that prevails in this part of the world. This year due to heavy snowfall, it remains closed for most part of the winter months thus obstructing the work. The continuous landslides in the Banihal-Ramban sector and drainage failures have led to increase in maintenance work in this sector. Thus every year, its maintenance cost increases and consumes a lot of funds.

## Solutions

1. The cement mainly Chunam and Ferro-cement used in the construction of rigid pavements should have the initial curing time of less than 2.5 h and final setting time of not less than 5.2 h. The aggregates of granite and carbonate rocks can be used.
2. The sub-base thickness of not less than 0.5 m should be used to prevent frost heave and differential settlements.
3. The construction of toe-walls mainly the mass gabion walls to prevent the low-amount landslide debris from entering the road that may damage road pavement and drainage.
4. The cut-off drains with trapezoidal cross-section should be provided at numerous places for better drainage.
5. To arrest relatively loose soil, catch fences mainly of brick, cement mortar or stones that are abundantly available can be used.
6. To prevent individual cracking caused due to penetration of moisture because of prolonged rainfall, crack sealing comprising of jute fiber mixed with cut-back bitumen can be used.
7. To repair large distressed area, the patch work can be done, fog seals constituting asphalt emulsions and water, chip seals in the form of bituminous layer and slurry seals bituminous emulsions can be used for surface treatment.
8. Increasing vegetation is the effective method to prevent soil erosion, snow drifting and weathering
9. To prevent snow drifting, the snow fences can be constructed and the roads have to be placed parallel to the wind direction.
10. The blind ditch can be constructed, and the permeable geotextile can be introduced on the top surface and the side of seepage layer to allow seepage into the ditch. The bottom and sides must be impermeable to prevent seepage into the embankment.
11. The insulated multiple-drainage outlets, snow walls and culvert can be used. The wall height should not be less than 3.7 m.
12. A flexible drainage can be used in landslide prone areas, because small cracking will not affect their operation.

## Conclusion

Thus from our study we conclude that it much more difficult to construct and maintain road in the cold and hilly regions like that of Kashmir valley. We identified the challenges and found some suitable

challenges to counter them. It was found that the major construction and maintenance challenge is to construct roads in the frost covered regions. The area being more prone to earthquakes because widespread landslides that increases the maintenance work and costs of the road, thus hampers the traffic flow on the road and halts the maintenance process. The another challenges identified was the mass movement of earth leading to the closure of roads, that cause heavy damage to road besides inconvenience and danger to the travellers due to heavy traffic jams. The best solutions were identified to overcome these challenges that are economical, feasible and easy available.

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