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Road Construction in Hilly Region and Their Problem and Solution

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Abstract - **Construction of road is very much important for the transportation of goods and services from one place to another by the mean of roadway network. Road transportation is one of the primary modes of transportation since from the earlier time. The mode of road construction is varies with the geographical feature of the earth such as plain land, mountain terrain, steep and hilly region. It is more easy and accessible to construct a road in plain region as compare to the hilly region.**

This paper presents the road construction mode in the hilly region as well as their problem and solution with reference to the segment of NH-13 from Sagalee to Midpu (Doimukh). Hilly region comprises of steep mountain terrain, naturally hard rock strata and various turning points which made the road construction very difficult. As the development take place so it is necessary to connect the every corner of the country in order to have a transportation facility easy and accessible in terms of commercial purpose ,business purpose ,health and medical services , education sector etc. Therefore construction of serviceable road in hilly region is very much important for the overall Nation growth. The review study of this paper is to bring the knowledge of road construction problem and their solution of particular hilly region road stretch from Sagalee to Midpu (Doimukh) which is the capital region of Arunachal Pradesh, having stretch length of 74 km.

Keywords - **Hills road, road construction, Trans Arunachal highway (NH-13), problem and solution.**

I. INTRODUCTION

1. In general (Road Network in India);

India has a vast and well-knit network of roads and highways. The network consists of 3 79,241 km of National Highways, 1,31,899 Km State Highways and 31,17,763 km other category road Though the network of roads and highways is mostly concentrated in the plain lands, the hilly and mountainous regions of country are also connected by different categories of road. Data on length of hill roads in India is not available. It is an established fact that the cost of construction and maintenance of hill roads is always more than that of a similar road in the plains.

The Indian government, in its budget allocates substantial amount for the construction of new roads, capacity augmentation and maintenance of the existing road network. The hill roads in the Himalayan range are mainly in the northern states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand and eastern states of Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram and Nagaland. These states suffer natural disasters from landslides, flash floods during the monsoon and also experience rare occurrences of cloud bursts, severe earthquakes and avalanches. These cause damage ranging from minor blockage to total destruction of the road formation and disconnect villages and towns for several days. With the growing need for new metalled roads to connect villages, capacity augmentation of existing roads and human activities on the hill slopes, the slopes are becoming more vulnerable to such natural disasters. Due to unplanned alignments and cross-sections adopted, hill roads often become more prone to damages from natural From the nature and type of natural disasters that occur in the hilly regions of India, the key physical parameters can be identified.

These parameters can be addressed to minimize the damaging effects through an adaptive geometric design. The geometric design standards and cross-sectional elements of the road need to be flexible to the terrain, the geographic and geological characteristics of the area to produce a sustainable design of the hill roads. When a mountainous road is poorly planned and constructed without well-designed drainage systems, it may lead to destabilization of hill slopes and soil erosions, which provide pathways of sediment transportation into streams and rivers. These results in degradation of water quality, aquatic habitation, and reduction in the agricultural productivity due to loss of top soil the landslide causes causalities and damages. There are instances where a lack of engineering geological or geomorphologic appreciation has led to recurrent problems, leading to redesign and even alignment modifications. Elsewhere, engineering geology has provided sufficient information and interpretation to enable designers to proceed effectively, and the evaluation

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of slope and drainage hazards as past, recurrent and potential future risk elements has required geomorphologic assessment as the critical path activity. A sustainable highway should satisfy the functional requirements of societal development and economic growth while reducing negative impacts on the environment and consumption of natural resources.

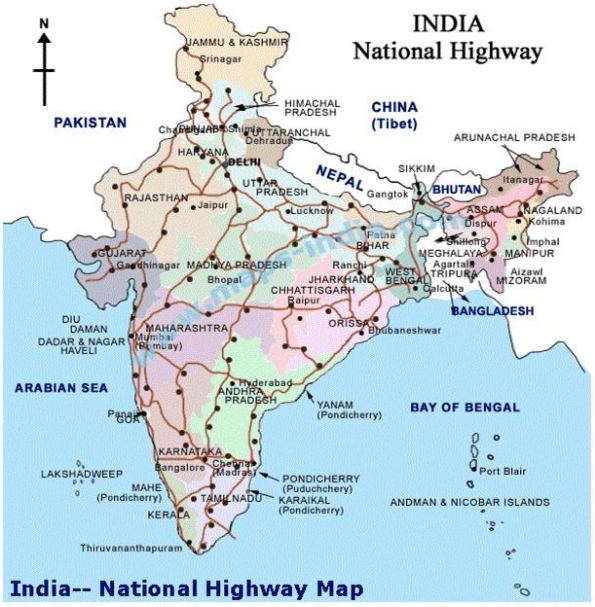

Fig.1. Map showing the Road Highway network of India.

The Indian Road Congress (IRC) codes have proposed remedial measures for critical site conditions in all cases through engineering solutions like:-

- slope stabilization
- soil stabilizations
- retaining structures
- cross drainage structures

Such solutions are sometimes not cost effective and short term measures. Design standards are based on terrain types classified as mountainous and steep. Design terrains are adopted based on the predominant terrain in the stretch which sometimes results in huge cut fill situations. In most practical cases solutions like alternate alignment in situations where a total avoidance of critical and natural disaster susceptible locations is required becomes costly and thus not adopted. As the chance of occurrence of a natural disaster is rare, the cost of maintenance and repair of damages is assumed to be incurred during the life of the road. A sustainable solution through adaptive geometric design can reduce the chance of damages and thus reduce cost of repair and maintenance of hill roads.

By addressing the geotechnical, geometric and construction issues simultaneously at the design stage for highways in hilly terrain the possibility and probability of damages to the roads due to natural disasters can be minimized.

2. In Particular (NH-13):

It is also known as “Arunachal Trans Highway’’. The NH-13 is also known as “Arunachal Trans Highway’’. The NH-13 is an under construction two-lane highway project in the Indian state of Arunachal Pradesh The highway extends from Tawang in the western part of the state to Kanubari in the east covering 1,559 km. The highway will connect 12 of the existing 16 district headquarters .The remaining 4 districts and the state capital will be connected to the "Trans-Arunachal Highway" by link roads which cover another 848 km. Its route will cost □ 100,000 million (US$1.4 billion).The Arunachal Frontier Highway along the China border, the trans Arunachal highway through the middle and Arunachal East-West Corridor in the foothills along the Assam border are 3 major highways spanning the whole state, thus India's Look East connectivity scheme.

3. Project Outline

The Trans-Arunachal Highway, a trunk route of about 1811 km in length, would be developed as a two-lane road to linkTawang in north-western tip of Arunachal Pradesh to Kanubari in south-eastern end of the State and finally ending on NH-52 near Akajan on the right side of Bogibeel bridge near Dibrugarh in Assam. The Highway, passing through the mid belt of the State, will inter-connect 14 out of total 20 district headquarters towns of the State and would thus provide improved connectivity to the state capital and important locations of population concentration and economic activities including the sites of major hydro electric power projects.

Within Arunachal Pradesh, the Highway will connect the district headquarters and other important places such as Tawang, Bomdila , Nechipu, Seppa, Sagalee, Yupia, Yazali, Ziro, Daporijo, Along, Pasighat, Roing, Tezu, Mahadevpur, Bordumsa, Namchik, Changlang, Khonsa, Longding, Kanubari etc. and help greatly in reducing isolation of the people of the state. Out of about 1811 km of the Highway, about 290 km forms part of NH-52 and 10 km of NH-153.

A length of about 1,850-km including link roads of Trans-Arunachal Highway has been declared as National Highway NH 52B by the Ministry of Shipping, Road Transport & Highways through a gazette notification. In addition 60-km 'missing link' between NH-57 and NH-37 connecting Dibang and Lohit valley in the state has also been declared as an extension of the NH-37. It will now be implemented by the ministry under the Special Accelerated Road Development Programme (SARDP) for the North-East.The □ 10,000 crore projects to provide a two-laned connectivity right through Arunachal Pradeshwill stretch out between the strategic Tawang areas to Mahadevpur ending near Dibrugarh in Assam. NH 52B will include 220 km of the existing NH 52 stretch, and will also touch Bomdila, Nechipu, Seppa, Sagalee, Ziro, Daporijo, Along, Pasighat, Roing Teju, Mahadevpur, Namchik, Changlang and Khonsa on the Nagaland border and Kanubari end route.

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Fig.2. Map showing the Trans Arunachal highway starting and end point at Tawang and Wakro respectively.

Fig.3. Map showing the NH-13 from Tawang to Mebo.

Fig.4. Map showing Mebo to Wakro (end point).

Fig.5. Map Showing route from Sagalee to Midpu (Doimukh).

II. LITERATURE REVIEW

A hill road may be defined as the one which passes through a terrain with a cross slope of 25% or more. There may be sections along hill roads with the cross slope less than 25%, especially when the road follows a river route. Even then these sections are also referred to as hill roads. Hence, to establish a hill road overall terrain must be taken into account.

The hilly regions generally have extremes of climatic conditions, difficult and hazardous terrains, topography and vast high altitude areas. The region is sparsely populated and basic infrastructural facilities available in plain terrain are absent. Hence, a strong stable and feasible road must be present in hilly areas for overall development of other sectors as well.

1. Design and Construction Problems

Design and Construction of roads in hills and mountain are more complex than in plain terrain. It is due to several factors associated in the region. They are:

1. A hilly or mountainous area is characterized by highly broken relief with vastly differing elevations and steep slopes, deep gorges etc. which may unnecessarily increase road length.
2. The geological condition varies from place to place.
3. Hill slopes stable before construction may not be as stable due to increased human activities.
4. There may be variation in hydro-geological conditions which may easily be overlooked during design and construction.
5. Due to highly broken relief construction of special structures should be done at different places. This increases the cost of the construction.
6. Variation in the climatic condition such as the change in temperature due to altitude difference, pressure variation, precipitation increases at greater height etc.
7. High-speed runoff occurs due to the presence of high cross slopes.
8. Filling may overload the weak soil underneath which may trigger new slides.
9. The need of design of hairpin bends to attain heights.

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2. Special Consideration in Hill Road Design

2.1Alignment of Hill Roads;

Selecting an alignment in the hilly region is a complex task. The designer should attempt to choose a short, easy, economical and safe comforting route.

2.2 General considerations;

When designing hill roads the route is located along valleys, hill sides and if required over mountain passes. Due to complex topography, the length of the route is automatically increased. Due to harsh geological conditions, special structures also have to be provided. Apart from the highly broken relief which has a fixed role in determining the alignment and location of special structures, climatic and geological conditions are also important.

In locating the alignment special consideration should be made in respect to the variations in:

1. Temperature
2. Rainfall
3. Atmospheric pressure and winds
4. Geological conditions

3. Temperature

Air temperature is in the hills is lower than in the valley. The temperature drop being approximately 0.5° per 100 m of rising. On slopes facing south and southwest snow disappears rapidly and rain water evaporates quickly while on slopes facing north and northeast rain water or snow may remain for the longer time. Unequal warming of slopes, sharp temperature variations and erosion by water are the causes of slope facing south and southwest.

4. Rainfall

1. Rainfall increases with increase in sea level.

2. The maximum rainfall is in the zone of intensive cloud formation at 1500-2500 m above sea level. Generally, the increase of rainfall for every 100 m of elevation averages 40 to 60 mm.

3. In summer very heavy storms may occur in the hills and about 15 to 25% of the annual may occur in a single rainfall. The effects of these types of rainfall are serious and should be considered well.

4. Atmospheric pressure and winds

1. It decreases with increase in elevation.
2. At high altitudes, the wind velocities may reach up to 25-30 m/s and depth of frost penetration is also 1.5 to 2 m.
3. Intensive weathering of rocks because of sharp temperature variations which cause high winds.

5. Geological conditions

1. The inclination of folds may vary from horizontal to vertical stratification of rock. These folds often have faults. Limestone or sandstone folds may be interleaved with layers of clay which when wetted may cause fracturing along their surface. This may result in shear or slip fold.
2. The degree of stability of hill slopes depends on types of rock, degree of strata inclination or dip, occurrence of clay seams, the hardness of the rocks and presence of ground water.

6. Problems in Hills Road

As per Bayan (1994, 1995, 1996, 2003, 2008 and 2010. (a&b)), there are numerous prevailing problems associated with smooth running of the NH-52(A) which is similar to the NH-13. Since inception.

Of course, all problems generate out of natural situation as well as of the prevailing unskilled engineering practices i.e. thumb rule nature of layman's practices.

However, studies made continuously since 1992 onwards based together on geotechnical investigations and direct observations overNH-52(A)road performance reveal the following principal categories of problems:

7. Geotechnical problems comprising -

1. Unsound subsoil condition including uniquely reveal weak CBR-values (Bayan, 2010)
2. Landslides due to static liquefaction and toe erosion of hill flanges(Bayan, 2013)
3. Revealing poor geotechnical parameters due to nature of origin of the subsoil arising out of immature geological formation (Bayan, 2013)

8. Hydrological problems associated-

1. With heavy rainfall and very poor system of drainage outlets (Bayan, 2010.b, 2004.)

9. Topographical problems associated-

1. With narrowing of pavement's width because of unprotected side falling of some critical pavement sections (Bayan, 2010.b, 1996, 1994 and 1992). In adequate suitable engineering knowledge for design and execution of any form of engineering measures to take care of the road pavement (Bayan, 2004.a 1996, 1994 and 1992 and Nani, 1995.b). At the initial stage of construction, authority of the NH-13 was state government. Subsequently, up to 1997 it was found that the bridge structures so erected over the major stream & rivers were washed out 2-3 times. The reasons are;-
2. Lack of basic practical engineering knowledge
3. Geotechnical behaviors of the sub soil forming the road pavements and its bases up to certain depth.
4. Effect of hydraulic energy on substructures as well as hydrological behavior of hilly rivers (Bayan, 2010.b, 2004.a, 1996, 1994.a&band 1992) on its subsoil forming its banks powered by heavy rainfall.
5. Good management of efficient drainage outlet system including perfectly designed and executed storm water drainages system needed at road side all along the total length of NH-13.
6. Updating engineering technical knowhow for implementations. However, during 1998-2009 bridge structures on the rivers turns to a preferable and durable phase of concrete structures under the engineering care of 1353 GE, BRTF, C/O 99APO.

10. Floods- The internal roads connecting Sagalee to Midpu (Doimukh) within the Capital are almost hilly roads and small portion of plain roads. The roads situated in plain area including the National highway (NH-52 A) that divides the State Capital region into two parts stretching from Itanagar to Sagalee via Doimukh, is

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the road of strategic importance. This road lags drainage system and is more prone to flooding, because it moves parallel to the river Pare. Whenever there are heavy rains during summers, it receives large quantity of water from its catchment area including various tributaries like subansiri, NEEPCO, Yazali Dam etc and it overflows, it inundates the national highway NH-13 viz, NH-52A and all the major Region of the Capital and their nearby village roads that comes in its way.

11. Landslide

The term landslides or less frequently, landslip refers to several forms of mass wasting that include a wide range of ground movements, such as downfall deep-seated slope failures, mudflows and debris flow. Landslides occur in a variety of environments, characterized by either steep or gentle slope gradients, from mountain ranges to coastal cliff or even underwater, in which case they are called submarine landslides. Gravity is the primary driving force for a landslide to occur, but there are other factors affecting slope stability that produce specific conditions that make a slope prone to failure. In many cases, the landslide is triggered by a specific event (such as a heavy rainfall, an earthquake, a slope cut to build a road, and many others), although this is not always identifiable.

12. Drainage System

In hills roads there is only one probable drainage side due to its geographical features. As one side of the road is steep toward the valley downfall where there is no provision for the drainage can be provided. On other hand the mountainous steep is there where drainage can be provided. But the due to the improper drainage system along the road length, the water from the stream, mountainous flow sometime overflow the road pavements which ultimately lead to the deterioration of the road surface as soon as possible.

Hilly region has got maximum rainfall throughout the year, so lack of drainage system is a major treat to roadway. Remedial Measurement for the problem in Hills road

1. Construction be followed the Geometric Design standard as per the guideline (IRC-52);

13. Pavement width

Table 1 Recommended design service volume for hill road

S.N.	Types of road	Design service volume in PCU/day		
		Carriageway width	Low Curvature (0-200 degree/Km)	High Curvature more than 200degree/Km
1	Single	3.75 m	16,00	14,00
2	Intermediate	5.5 m	5200	4500
3	Two Lane	7 m	7000	5000

Sr. No	Road type	Mountainous terrain		Steep terrain	
		Ruling	Minimum	Ruling	Minimum
1	NH & SH	50	40	40	30
2	MDR	40	30	30	20
3	ODR	30	25	25	20
4	VR	25	20	20	20

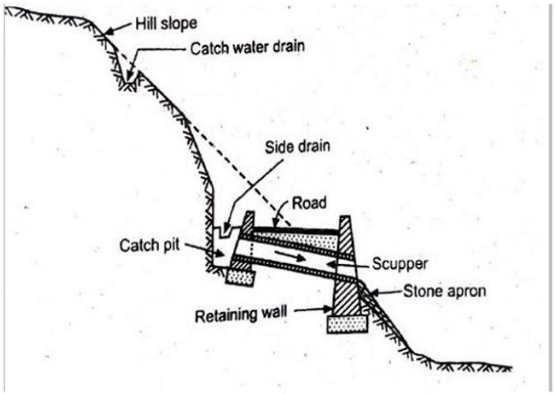
C. Camber
D. SSD
E. OSD
F. Gradient
G. Super elevation
H. Radius of horizontal curve
I. Widening of curve
J. Transition curve

14. Maintenance of Drainage Structure

The main problems that hill roads face are the harmful effect of water. Water may come from different sources to the parts of the road. This water must be drained using any means necessary. Drainage of hill roads can be studied under following sub-topics:

15. Drainage of water from hill slope;

Surface water flowing from the hill towards the roadway is one of the main problems in the drainage of hill roads. Since a large amount of water flows along with debris from the hill slopes during heavy storms, a catch drain is generally provided to catch the water in the middle of the slope. Water intercepted in catch water drains are then diverted by sloping drains and carried to the nearest watercourse or to culvert to cross the roadway. The figure below shows a layout for drainage from hill slopes



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16. Roadside Surface Drainage;

Side drains are provided all along the hill side of the road. Due to the limitation in the formation width side drains are usually constructed to such a shape that at emergency

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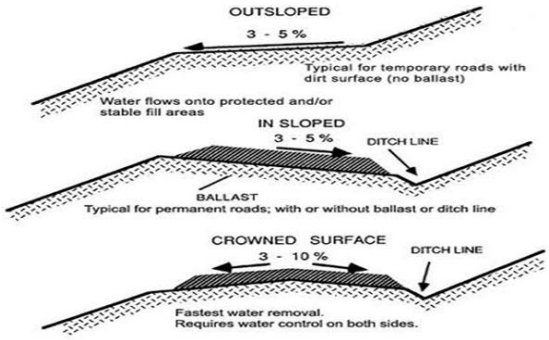
the vehicles could utilize this space for crossing. The shapes may be angular, saucer or kerb and channel drains



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17. Cross drainage

A cross drainage is always required on a hill road. The drainage must be taken under the road as far as possible. At the heads of the small cross drains, catch pits must be provided to collect debris and to prevent scouring.

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18. Revention of Landslides;

1. Falls (Free Flows)
2. Slides (Shear Falls)
3. Flows (Movement within displaced mass)
4. Complex Landslides (Combination)
5.

II.PROTECTIVE WORK

1. Retaining structures

A retaining structure is usually a wall constructed for supporting vertical or nearly vertical earth bank. Retaining walls are constructed on the valley side on the cut hill side to prevent the slide towards the roadway. Situations where construction of retaining walls is required:

1. Places where the valley side surface gets saturated in the monsoons and is likely to result in slip taking a part of the road with it.
2. Places where undercutting by a stream or other water course causes damage to the valley side and the road.
3. In valley point where water flows over the road
4. To achieve roadway width, where cutting into the hill is not economical or has to be restricted due to other reasons

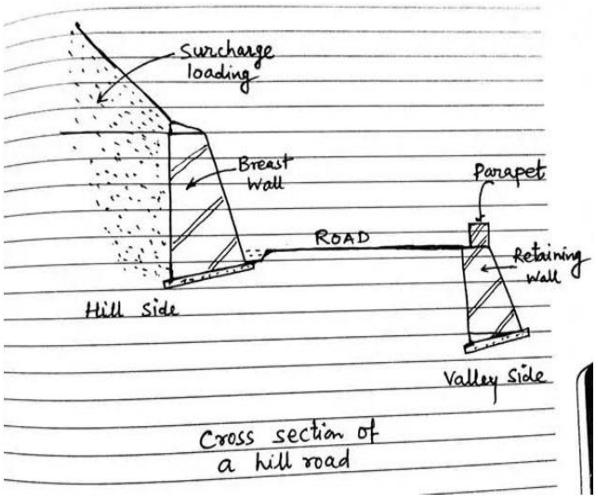

Fig.6. Retaining wall in Hills road.

2.Parapet Wall;

Wall which is provided above the formation level in the down side slope is called parapet well.

Function: Protection to the traffic against falling down the hill slope.

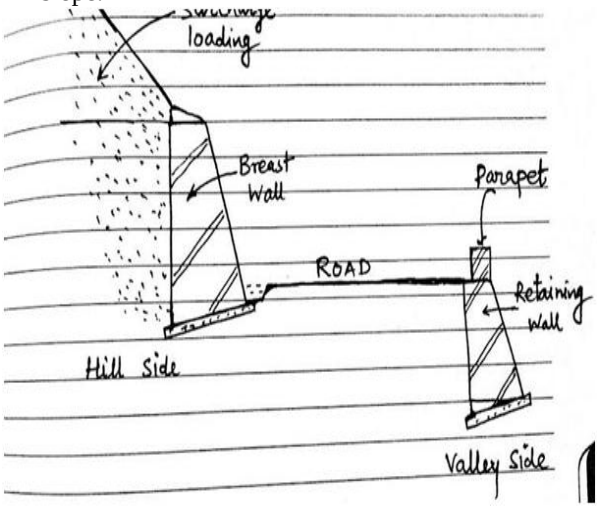

Fig.7. Showing Parapet.

III. SUMMARY

Present study was made review about the Road construction in Hilly region with reference to the road stretch from Sagalee to Midpu (Doimukh) which is the part of National highway (NH-13) Popularly known as Trans-Arunachal Highway. Also study was made on their construction problems and remedial measures to be carry out in order to improve the road quality in future subsequence of the hilly regions. From the study we found that the condition of road in hills region is dilapidate condition throughout the year just year after the completion of road construction. The reason for such deterioration condition of the road in hilly regions was found to be;

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1. Natural Disturbance due the topography feature such as Annually heavy rainfall
13. Floods
14. Landslide
15. Avalanche
16. Frost Action

2. Structural Failure such as

Lack of Protective structure (retaining wall, parapet wall, breast wall, culvert etc

No proper Drainage

3. Improper Design lead to early road failures;

1. Lack of skilled engineers
2. Improper survey while designing
3. Low Machinery and construction materials.

After examine the road failure in hilly region, study is also made on the solution for the problems that include the provision of protective structure as well proper design of the road alignment before the construction of the work to be carry out. With this review study we come to the conclusion that the road construction in the hilly region is not that of easy one, as it is most vulnerable to the natural phenomenon such as rainfall, snow fall, landslides, floods etc. But it is also not impossible for the engineering to tackle with the nature for some extends and giving outmost solution as possible as with the help of modern technology, guideline, research work, experiment work, field survey, case study etc. From which we can able to analyses the remedy for every problems. Such study gives innovative idea and new things to be implements when the present structure loss it quality. So in order to provide a quality road in hills region it is important to study the geology feature of the area, preliminary survey to carry out of proper man knowledge of the locality, followed by the protective structure as well use of quality construction materials which will gives comfortable rides and lasting road in a hilly region.

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