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Hill Road

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Abstract

It is always an important to construct a quality road in a hilly region in order to avail the various facility services within the region by linking the villages link road to the main state and national highway, so that the peoples in a hills station could able to travel from one place to others by means of good transportation services. In order to facilitate the systematic transportation within the State including the hills region need a proper construction of road with quality aspect that could last for the long duration which will provide a lifeline to the peoples residing in the region also will boast the overall standard development of the region, peoples, by accessing the basic facilities when ever needed such as agriculture marketing, education hub, health care, IT sectors etc.To construct a quality road services its need a proper guideline and specification which is to be followed up in terms of survey as well as technical methodology. There are various ways to construct a road but in hilly region there's extra precaution is required as compare to the plain road construction.

This paper present the concept of road construction in hilly region with newly area for the construction of road maintaining the IRC specification of hills road, methodology, problems and precaution measure to study the solution, materials uses, design and implementation and also future enhancement. For this purpose, the hills road of the Arunachal Pradesh has been studied from NH-13, (Sagalee to Doimukh) road length of 66km, which is the portion of TRANS ARUNACHAL HIGHWAY PROJECT.

Keywords: Hill road, methodology, design, problems and solution, future aspect

<u>CHAPTER:</u>

I. Introduction

A hills road is types of road which possess through the cross slope of 25% or more.Cross gradient is meant for the design of drainage purpose across the road. Mathematically it is express as (rise/run *100). There may a section along the hill road with cross slope less than 25% basically it is along the river route. Even they these sections are also referred to as hills road. Hence to establish a hill road overall terrain must be taken into consideration. The hills region has basically extreme climatic condition, difficult and hazardous terrain, uncertainty topography, and vast altitude areas. The region is less populated and basic facility such as infrastructure is not available as compare to the plain terrain.

Goal and Objectives:

The main goal and objective of the hill road construction is same as that of the plain terrain where road network is very essential for the overall development of the region irrespective of the infrastructure, basic needs are all fly over the road. Therefore, good quality road construction is very much needed in any location. In hilly region the construction of road is more complex as compare to the plain terrain. It is due to several factors associated in the region. They are:

a) 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.
b) The geological condition varies from place to place.
c) Hill slopes stable before construction may not be as stable due to increased human activities.
d) There may be variation in hydro-geological conditions which may easily be overlooked during design and construction
e) Due to highly broken relief construction of special structures should be done at different places. This increases the cost of the construction.
f) Variation in the climatic condition such as the change in temperature due to altitude difference, pressure variation, precipitation increases at greater height etc.
g) High-speed runoff occurs due to the presence of high cross slopes.
h) Filling may overload the weak soil underneath which may trigger new slides.
i) The need of design of hairpin bends to attain heights.

That why there is lacks in the transportation communication within the hilly region due to the absence of quality road and maintenance factors.Thus, objective is to make a stable and feasible road that must be present in hilly areas for overall development of other sectors as well.

Motivation:

Major region of India geographical area is of hills station right from the Jammu & Kashmir to North-Eastern part of the India that including the state of Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Tripura, and Sikkim. These states usually suffer natural disaster like flood in river basin, landslide, severe earthquake and avalanches. These causes damages ranging from minor blockages of road to major cut off of the road during the naturals calamities, which leads to major setback in the road communication like disconnect the various villages from the town for several days results in many problem in getting the basic facilities such as emergency health care, local markets , daily wage labours etc. India has road network of 3,79,241 km National highway, 131899 km of State Highways and 3117763 km of others category road through which the most of the road section is concentrated in the plain land. The hills road is connected by different categories of road. Data on the length of hills road is not available. It is an established fact that the cost of construction and maintenance of hills roads is always more than that of a similar road in plain terrain.

There is lots complexity in order to construct a road in hilly region due to various factors like topography, environmental issues, Govt approval, machineries tools and agency availability etc. So, I being the citizen of India belong to the hill state known as Arunachal Pradesh, professional by civil engineering is being solemnly motivate to work on this issue so thus worked on this paper to study the road construction in hilly area of Arunachal Pradesh, India.

Overview of the Technical area:

1. Geometric Design Aspects of Hill Roads:
   a) Right of Way or Road Land Width:

Desirable values of width are given below:

Table: 1

Desirable Land width (m) IRC: 52-1982

S.no.	Road classification	Open Area		Built up Area	
		Normal	Exceptional	Normal	Exceptional
1	NH & SH	24	18	20	18
2	MDR	18	15	15	12
3	ODR	15	12	12	9
4	VR	9	9	9	9

b)Width carriageway, shoulder and roadway are given below:

Table: 2

Carriageway, Shoulder, and Roadway width (m) (IRC:52-1982)

S.no.	Road Classification	Width (m)		
		Carriageway	Shoulder	Roadway
1	NH &SH Single Lane	3.75	2*1.25	6.25
2	NH &SH Double Lane	7	2*0.90	8.80

3	MDR & ODR	3.75	2*0.5	4.75
4	VR	3	2*0.5	4.00

c)Camber or Cross Fall:

On straight sections, the recommended values are given below:

Table: 3

S.no.	Road Types	Camber (%)
1	Earth road	3 – 4
2	Gravel or WBM	2.5 – 3
3	Thin bituminous surface	2.0 – 2.5
4	High type bituminous surfacing	1.7 –2.0

The camber for shoulder should be 0.5% more than the pavement value, subject to a minimum of 3%. On super-elevated section, the cross-fall of shoulder should be the same as that for the pavement.

d) Design Speed:

The design speeds for various categories of hill roads are given below:

Table: 4

Design speed (km/hr) (IRC: 52-1982)

S.no	Road classification	Mountainous		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	25	20

Normally ruling design speed should be the criterion for correlating for various geometric features; the minimum value may be adopted where the site condition do not permit it.

Drainage Aspects of Hill Roads:

The drainage practices relevant to hill roads are given below:

a) Camber:This has already been covered under geometric design. This ranges from 2 percent (1 in 50) for high type bituminous surface to 2.5 to 3 percent (1 in 40 to 1 in 33) for WBM/gravel surface.
b) Side-Drains:These are provided only on the hill side of the road. The size of the drain may be 0.60 m x 0.45 m of triangular shape and is unlined. Kerb and channel type of drain is recommended and is popularly used

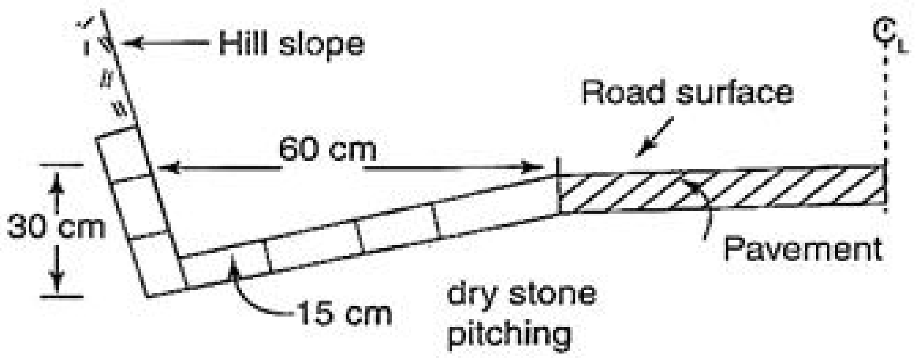

Fig: 1

c) Catch-Water Drain: They are used to intercept the surface run-off from the hill slope, drain it parallel to the road and lead into a cross-drainage structure such as a culvert at a convenient location.

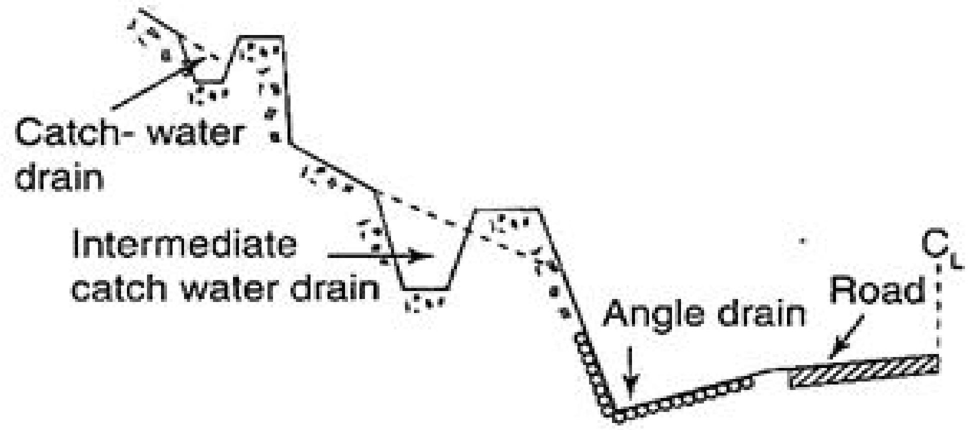

Fig: 2.

It is necessary to design these for no overflow and for avoiding high velocity flow; it is therefore preferable to pave the bed and the sides.

d) Cross-Drainage and Protection Works:Cross-drainage works such as culverts, causeways and scuppers have to be provided at reasonable intervals along the road to drain off the water from catch-water drains and side-drains to a safe location away from the road.

For important hill roads, culverts – pipe culverts, slab culverts and arch culverts – and minor bridges should be designed and constructed at appropriate intervals along the length of the road.For minor or unimportant roads with low volume of traffic, causeways (or submersible bridges) and scuppers (or dry masonry coursed rubble culverts), which are less expensive may be provided.Turfing the slopes is a good protection measure to prevent erosion.

e) Sub-Surface Drainage:

The seepage flow and high ground water table may cause problems of stability underneath the roadway. Seepage flow may cause stability problems for the hill slope too.

Hence, a suitable sub-surface drainage system consisting of longitudinal and/or cross, drains, may be designed and constructed depending upon the depth to hard strata, amount and intensity of rainfall and other pertinent factors.

Maintenance Aspects of Hill Roads:

The following are the maintenance aspects of hill roads:

a) Maintenance of drainage structures: The various component structures of the drainage system such as side-drains, catch-water drains, cross-drainage works such as scuppers, culverts and causeways, and sub-surface drains, if any, have to be cleaned periodically to remove the silt and other extraneous materials, so as to allow smooth flow of water.

As a precautionary measure, Turfing and planting of trees on the hill slopes tend to reduce the velocity of the surface run-off and prevent the scouring action and erosion of unstable earth material.

b) Clearance of snow in snow-bound areas: In snow-bound areas such as the Himalayan region, the problem of snow-cover on the road is acute, especially during winter months. Compacted snow surfaces are dangerous and are traffic hazards; hence the need to remove snow and ice as fast as possible. Snow markers or wooden poles with metre divisions marked on them are erected before the onset of winter. These will help locate the roadway and estimate the amount of snow clearance needed.

Machines such as dozers, motor graders, blade ploughs, and rotary ploughs are used for snow clearance. Even blasting the ice is resorted to if the ice crust is very thick.

In some cases, salts such as sodium chloride and calcium chloride are applied to bring about melting of ice at temperatures less than 0°C. Normally, 90 to 180 kg of salt is needed per one-kilometre-length of a two-lane road.

c) Prevention and correction of landslides: Landslides are a very common problem encountered in hill roads. These are common in geologically young hill ranges. During the construction of roads, a lot of cutting of the rock is involved, which disturbs the natural conditions and the balance of forces. Slips, subsidence (or significant settlements), and landslide will result.

Increase in shear stress and reduction in shear strength are primary reasons for the occurrence of landslides, from a geotechnical engineering point of view.

1. Possible causes for increase in shear stress are:

a) Cuts and quarrying, removing part of lateral support.
b) External traffic loads, weights of structures, and water in reservoirs.
c) Increase in surcharge due to snow.
d) Increase in pore-water pressure.
e) Earthquakes and blasting operations.

2. Reduction in shear strength may be caused by:

a) Swelling and pore-water pressure increase.
b) Alternate swelling and shrinkage, leading to cracking and subsequent inundation.
c) Presence of faults, discontinuities, joints and cleavage planes.
d) Seepage pressures of percolating water.
e) Tree roots and burrowing by animals.

3. Techniques of Prevention and Correction of Landslides:

a) Effective drainage measures like catch-water drains
b) A forestation
c) Provisions of French drains as part of sub-surface drainage.
d) Grouting and rock bolting.
e) Provision of check-walls, breast walls and toe walls.
f) Turfing and growth of vegetation on slopes.
g) Chemical treatment.
h) Jute-netting and Wire-netting.

d) Control of Avalanches:Avalanches are large-scale slides of the material on hill slopes. These are very hazardous as they occur without much notice and cause damage to the hill road and the ancillary structures. Avalanches are common in snow-capped mountain ranges such as the Himalayas. So, road construction in such zones should consider measures to minimise the damage due to avalanches.

Special protective measures such as galleries are constructed above the road, which allow the rolling mass of snow-over the gallery roof, thereby preventing damage to the hill road and harm to the road users.

The gallery is constructed on a bench of a cutting and covered with natural earth. R.C.C. galleries are popular for their flexural, compressive and impact strengths

II. Literature Review

1 Introduction:

Development of a country depends on the connectivity of various places with adequate road network. Roads are the major channel of transportation for carrying goods and passengers. They play a significant role in improving the socio-economic standards of a region. Roads constitute the most important mode of communication in areas where railways have not developed much and form the basic infra structure for the development and economic growth of the country. The benefits from the investment in road sector are indirect, long-term and not immediately visible. Roads are important assets for any nation. However, merely creating these assets is not enough, it has to be planned carefully and a pavement which is not designed properly deteriorates fast. India is a large country having huge resource of materials. If these local materials are used properly, the cost of construction can be reduced. There are various types of pavements which differ in their suitability in different environments. Each type of pavement has its own merits and demerits. Despite a large number of seminars and conference, still in India, 98% roads are having flexible pavements. A lot of research has been made on use of Waste materials but the role of these materials is still limited. So, there is need to take a holistic approach and mark the areas where these are most suitable.

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. Highway planning process requires a comprehensive evaluation of future conditions in the geographic region which may be impacted by the construction of a new highway. For example, construction of a new highway may change the land accessibility and land use pattern in its area of influence. Such changes should be considered very carefully **(Jha 2006).**

Planning roads in hilly terrain is much different from plain and rolling terrains. Strategic points cannot be connected straight in hills as they are scattered and located over slopes at different altitudes. Therefore, the alignment is circuitous and is primarily governed by topography. While constructing roads, it has to be ensured that the ecosystem is not disturbed and judicious balance is maintained between road development and environment. Disturbance to any unit of environment will upset the ecological balance and lead to destruction. The roads in hilly regions are aligned in ecologically sensitive forest and mountain located in unstable terrain conditions subject to extremes of climates and prone to landslides and flooding. Highway projects have impact on the physical resources such as drainage, surface water quality, air quality, soils and noise levels. Proper dimensioning and coordination of the different design elements can significantly improve the safety performance, 11 produce a visually pleasing facility, and eliminate the needs for further costly improvements and reconstruction of hazardous sections **(Hassan 2004).**

In view of environmental importance, it is important to include mitigation measures at the planning stage of road projects that may even involve changing the horizontal and vertical alignments. Reduced pollution and economy from operating vehicles is achieved by adopting easy grades, minimizing rise and fall and following straight line connection between obligatory points. Although shortest path is an important factor, in order to obtain easy curvature and gradients, to avoid prohibitive cuts or fills and long river crossings it may have to be reconsidered. Manytimes, a longer road length to ease gradient and curves may result in an economical and environmentally friendly stretch (IRC SP: 48 1998)

2. Survey:

Road Alignment Survey:

Roads are geometrically defined spaces on the earth surface primarily meant for including motorized vehicles. Different elements of this space, such as width, radius, sight distance, geometrics, gradient and carriageway composition are needed to have standardized shape and size. Defining of these shapes and sizes is what is determining basic geometric parameters. This depends upon the topography and soil condition on which the road is constructed and type of vehicles. Geometric parameters of different elements shall be considered throughout the alignment of the road uniformly and these points are to be kept in mind during the alignment survey work (RRTDM 2012). Alignment survey work consists of reconnaissance survey, preliminary survey and final location survey. During reconnaissance survey the obligatory points and control points are to be selected apart from identification of favourable and unfavourable locations to take the alignment. 12 Guided principles and code provisions are to be followed at most care during such process. After completing the reconnaissance, next comes the preliminary survey work to mark the gradient line using ghat tracer and levelling instruments. Using prepared longitudinal section using the levels, the vertical profile of the alignment will be designed. It is also necessary to do compass survey to prepare the plan of the alignment to design it according to the recommended standards. Avoiding deep cuttings, providing cross drainage structures at appropriate locations, well located hairpin bends, uniform gradient and environmental safety would make the alignment better. Decisions made at the route selection stage may have long-term effects on safety, maintenance and operation costs. Therefore, it is essential to allocate sufficient time and resources for this task. It begins with the activities of collecting and analysing of all the available information of the project area. This information may include:

a) Aerial photos
b) Topographic maps
c) Soil erosion potential maps
d) Land alienation maps
e) Geological maps and drainage maps (FPCBC 2002).

Modern techniques in hill road alignment:

Many literatures are available to highlight the use of modern techniques such as Remote sensing, GPS survey and GIS in the planning and survey of ghat roads. **Asmaa (2011)** have explained the capabilities of GIS technologies in different fields of civil engineering such as hydrology, hydraulics, water resources, transportation, geotechnical, surveying, environmental etc., to facilitate engineering analysis, modelling, design, implementation, management and decision making. He also highlighted its potential to solve space related problems of construction involving integration of information, project site selection, soil studies, hydrology and environmental issues.

Zhongzhen et al (2003) have tried a new method to optimize highway location, which combines road engineering and traffic 13 demand model and takes GIS and AutoCAD as tools to process data, spatial calculation and detailed design. This method took both economic and environmental aspects into account when deciding a new highway location in road network from both macro and micro level duly considering noise and vibrating pollutions.

Basim et al (2008) have concluded in their study that the Ground Control Points (GCPs) required in field surveying of engineering projects shall be identified easily through the method of using enhanced satellite images of high resolution. They have also investigated elevation difference between the points in field measurements with the corresponding points in DTM measurements and found the percentage of coincidence was about 82% recommended the use of DTM in future works for highway design as a replacement to the conventional methods of preliminary design and surveying.

Remote Sensing, GIS (Geographical Information System) and GPS (Global Positioning System) Survey:

There are considerable costs associated with conventional surveying technology. These methods are time-consuming and often require multiple trips to the same site to gather data and to ensure that the collected data is accurate. In addition, workers must be trained to operate conventional surveying equipment properly. Weather also can delay data collection and highway surveys; crews are not always able to work under adverse weather conditions, such as snow, rain, or extreme temperatures. The Utah Department of Transportation found that one-person operating GPS equipment is generally twice as fast as a conventional survey crew, and a GPS system with two units is potentially four times faster than crews using conventional surveying technologies. Other advantages of GPS technology include the ability to use the technology across long distances with minimal setups (USDT 2003).

Hala & Ossman (2013) have concluded that the use of 14 GIS and shortest path algorithms in the early planning system would result in time saving and sustainable corridor location design and it can avoid many location problems apart from giving several alternatives.

Srirama et al (2001) have done similar work and concluded that by using GIS in highway route alignment, one can compare as many alternate routes as desired in a very short period of time consisting of large amount of highway route alignment parameters without any extra cost.

Jin-Soo et al (2008) have reported that, laser scanning technology on highway has a great potential for the faster and more accurate geometric information extraction within highway geometric information system that is about to be developed hereafter.

Selcuk et al (2003) have computed cut and fill volumes of various forest roads using GIS techniques after construction. They said that, in practice using these computations before the construction of the roads in the phase of forming different alternatives will reduce the money and time spent on planning forest roads on a great scale.

Uddin (2008) presented some results of a recent study that has evaluated data accuracy, efficiency, and cost effectiveness of remote-sensing LIDAR (Light detection and Radar) technology as compared to the conventional aerial photogrammetric and ground total station methods for terrain data acquisition and mapping. An overview of airborne laser mapping technology for producing digital terrain models and digital databases for highway planning and design applications and accuracy are analysed.

King & O'Hara (2001) in their study found the effectiveness of the LIDAR technology in the wooded and vegetative areas where the LIDAR data can produce a bare-earth digital terrain model of the surveyed area useful for future planning and design of any highway facilities or improvement. The selection of an appropriate alignment for a proposed highway is determined largely by relating topographic, land use and environmental 15 features to geometric design controls. Typically, aerial photographs and topographic, geologic, and soil maps are reviewed in the process.

(Sadek et al 1999)using the GIS and a geographically referenced database, a decision-aid tool for multicriteria evaluation of route alignments can be developed and possible alignments are evaluated based on community disruption and environmental, geotechnical, and geometric design criteria

Tae-Ho et al (2003) have explained in their paper about the importance of perfect alignment and the methods to correct imperfect alignments using GPS. They have also compared precision of traditional design drawings with the drawings prepared using GPS and GLONASS (Global navigation and satellite system) and evolved an effective and useful approach to utilize satellite road alignment system by evaluating the existing horizontal alignment of roads.

Chuqing & Ying (2014) presented in their study a novel method for road centreline extraction from aerial imagery in a fully automatic approach that addresses the challenges of different road shapes, complex scenes, and variable resolutions by exploiting road GPS data. The proposed method combines road colour feature with road GPS data to detect road centreline seed points. After global alignment of road GPS data, a novel road centreline extraction algorithm is developed to extract each individual road centreline.

Priyanka & Surajit (2013) have studied the application of DEM and said that the DEM analysis not only explain characteristics of geomorphologic features but also support a good data base for different other economic and ecological planning works. They also explain the use of DEM in relief zoning, aspect analysis, and drainage overlay.

Mohd & Kamaruzaman (2009) have said in their study that the engineering practices on forest road alignment are often hindered by costly environmental and operational assessment. Use of GIS tools and remote sensing data will facilitate the allocation suitable forest access road by taking consideration of environmental and cost implications. 16 The aim of their study is to present a method to integrate remote sensing data and GIS for the purpose of allocating access roads for forest harvesting using best path modelling.

Geotechnical Factors:

Due to the inherent nature of complex topography, geology and environment, design and construction of road in hilly terrain demand special considerations.

Moh & Woo (1986) have discussed site investigation including hydrological information, geological mapping, geotechnical analysis of cut slopes and embankment fills and slope stabilization. They also highlighted the significant role of slope instability and landslides and discussed the methods of landslide prevention and control.

Grapel & Skirrow (2012) have concluded that the findings of a Functional Planning Study (FPS) are to be considered at the highest level of decision making authorities and the justifications shall be used for supporting different options of the proposed project which vary from site to site and region to region and depend on many factors. From the perspective of the geotechnical engineering, it must be recognized that the recommendations made on the preferable route that has less risk associated with geohazards will be balanced out against long standing established transportation corridors, trade routes, historical costs and investments, from both operational and societal perspectives.

Rao et al (2006) have explained in their work about the use of GIS as a cost-effective tool to identify optimum route alignment using land use, soil, slope, geology, aspect and drainage and elevation data as input parameters. They have also elaborated the problems in ghat road survey works and time-consuming conventional survey methods to extract surface profile information required for road alignment planning.

Volkan (2006) have pointed out the difficulties in manual marking of segments of permissible gradients for route alignments on topographical maps and on the site and 17 discussed about the capability of GIS in handling large data and automating route selection process using multi criteria analysis and its universal applicability. They have also highlighted the use of raster maps and models that give wealth of terrain information surrounding the alignment and suggested genetic algorithm to optimize highway alignment for improving computational efficiency. They have pointed out that subdividing larger lengths into suitable pieces can decrease the computation time and give better solutions.

Earthwork Optimization:

Easa (1988) and Cheng (2013) integrated the selection of roadway with earthwork volume calculation. Reliable and accurate earthwork volume calculation is one of the most important components in roadway engineering that can influence the choosing of roadway alignment, the cost and construction. The earthwork volume is one of the most important objectives in horizontal and vertical alignment optimization, so most researches firstly focused on the cut-fill balancing to minimize the cost.

Jian (2013) used grades and reduced earthwork into one problem by enumerating all technically feasible grades and solved the problem using linear programming techniques.

Aruga & Sessions (2005) developed a forest road design program based on a high-resolution Digital Elevation Model (DEM) from a light detection and ranging (LIDAR) system. After a designer had located the intersection points on a horizontal plane, the model firstly generated the horizontal alignment and the ground profile, and then it could precisely generate cross-sections and accurately calculate earthwork volumes using a high-resolution DEM. A shortage of this model was that it couldn't properly optimize horizontal and vertical alignments simultaneously.

18 Du & Teng (2007) used 3D laser scanning and GPS technology to compute volume of landslide earth volume. They employed these two advanced technologies to create the contour after landslide. The original contour of this area could be obtained from the government departments. The volume of collapse was estimated by the difference between before and after landslide of terrain contours by the contour method with the Simpson's rule. However, the real and accurate volume could be got by DTM method, especially with the help of updated CAD software, GIS, GPS and laser scanning technology **(Uddin 2008)**. With the purpose of considering the influence of different longitudinal design line on the earthwork computation result, **Jian-chuan & Long-jian (2013)** studied this with the index of CRCF-Change Rate of Cut Fill, namely the number of intersection points between vertical alignment and original ground level (OGL) line in one kilometre-to evaluate the different cut-fill condition of the roadway. Smaller value of CRCF indicates that the vertical alignment and ground profile intersects less, so it could be the section with deep cuts and fills of earthwork. Larger CRCF value on the contrary indicates the vertical alignment is close to the ground profile but with frequent changes between cut and fill.

Drainage and cross Drainage structure:

David et al (1998) have described in their work about the use of GIS in the preparation of flood plain mapping, geo referencing hydraulic models and integrating them in digital terrain model and combining data on the general landscape with stream channel data.

Mazumder (1998) has studied different methods of discharge computation along with the characteristics of mountain streams and selection of appropriate sites for cross drainage structures with less cost and adequate safety. It is also discussed in his paper the linear waterway calculations for cross drainage structures using Lacey's 19 equation optimum spacing of cross drainage structures and transitions of inlets and outlets. Examining the hydrology and terrain is an essential preliminary requirement for any consideration of drainage. If potential sources of water are not identified correctly, then it will not be possible to design the drainage properly to protect the road **(TRL 2002).** Road drainage can affect the natural environment in different ways, depending on the characteristics of the local environment. Rural road engineers need to be able to identify those types of environment that are of particular importance, and understand why they are of importance, to enable them to decide how they could be considered in the design of road drainage **(Griffiths 2002).**

Liu & De (2005) have prepared models to predict flood hydrographs and spatial distribution of hydrological characteristics of a watershed using elevation, soil type and land use data. The model was tested for small catchments by obtaining soil data from GIS and land use and soil cover from remote sensed images. They found it suitable for simulating hydrological processes in complex terrain and to predict the influence of changes in land use on the hydrological behaviour of a catchment area.

Environmental degradation and mitigation:

Saha et al (2004) have studied road planning in areas highly susceptible to landslides. In their study, in a test area in the Himalayas, they have considered various thematic layers, viz. landslide distribution, landslide hazard zonation, land cover, drainage order and lithology to find out safe landslide free route using Remote Sensing and GIS techniques. They have also studied the different nature of environmental degradations caused by road construction and its effects on small and larger geographical areas during construction or with subsequent road presence, upkeep, and use.

Mark (1994) in his report provides guidance for the analysis of ecological impacts from 20 highway development activities and the evaluation of related ecosystem mitigation measures by optimizing cut and fill volumes of earthwork.

Hareram (2010) has discussed significant effects of road construction on slope stability, drainage, erosion and sediment supply to drains. He had registered his views on the practice of excessive cutting and throwing and its adverse environmental effects through induced landslides and insisted upon the balanced method of excavation. He also summarized the recommendations meant to reduce negative road effects.

Sreeramamurthy et al (2012) have attempted to correct the grade of alignment and non-standard curves of the hill top road from Hanumanthawaka to Simhachalam, near Visakapatnam in India, in their work. They found the stretches of the road having grades more than the exceptional gradient and suggested alternate alignments with ruling gradients as per the code provision of Indian Roads Congress (IRC). The survey methods they adopted, corrections made to the non-standard curves and hairpin bends, environmental benefits and cost savings have also been discussed.

Conclusion:

Hill road construction is a special subject that needs continuous investigation to make it more adoptive to the terrain where it is planned for implementation. It has many criteria under different domains such as safety, economy, environment and aesthetics and different elements such as road cross section, horizontal and vertical alignments, hairpin bends, super elevation, sight distance, formation width and protective works. Things what we adopt for road formation in plains will not be suitable for hill roads in many aspects. The road geometrics such as horizontal and vertical alignments, drainages, cross drainage structures adopted for hill roads are all different from the one we usually adopt for the roads in plains. The horizontal and vertical alignments should coordinate with each other to form safe and aesthetically pleasant alignment in hills. Though shortest alignment between two points is a straight line, practically it is possible only in a few cases and therefore it is necessary to find out the alternatives with different plan and profiles. The common requirements for a hill road alignment are minimum length, fixed gradient and good coordination of horizontal and vertical curves. These three requirements are important as they have association with the optimization of alignment and construction cost and are generally not addressed sufficiently in the conventional alignment optimization methods (**Fwa et al 2002**). 2 Conventionally, investigation for hill road formation starts with studying topographic and contour maps of 1:50,000 and 1:25,000 scales followed with reconnaissance survey and site visits. Sometimes it includes studying of aerial photos and stereoscope study of the terrain images. Based on the observations of the team, obligatory and control points would be fixed to start and finish the alignment along them. The instruments used are ghat tracer, levelling instruments, altimeter and theodolite. Alignment of the road is traced from the top to bottom using ghat tracer. During this part of activity, the work has to be repeated many times to trace the alignment at a fixed gradient between 5 percent and 7 percent. Lot of man power is required to complete this kind of work apart from the long periods of time it consumes. Special arrangements are to be made for water, food and stay, in remote locations having adverse terrain conditions. The team members have to prevent themselves from insect bites and injuries that may be caused by sharp thorns of jungle plants. Therefore, studying and comparing many alternatives are rather difficult and hence normally two or three alternate alignments are considered and the best one is finalized.

Use of modern techniques in hill road alignment planning will considerably reduce the time and manpower requirement. Further it will reduce the construction, maintenance and vehicle operation costs as it would help to evolve a most competent route among the alternatives. Therefore, finding a systematic method for ghat road alignment survey will give the highway community a great deal of ebullience. This study is focused on this aspect and will elaborate a systematic approach to the survey of ghat road alignment so as to reduce the inconveniences faced in the conventional methods. Remote sensing is a modern age tool and its applications are wide and versatile and are being used in all fields of engineering. For map study, terrain data analysis and elevation and aerial view study remote sensing is an appropriate application. It is highly useful in preliminary field studies and to find out obligatory and control points. One can use various remote sensing data, available either through free source or paid source, to develop different field models of contours and DEM to study the area or to directly use the remote sensed images of the area such as google earth images. The interpretations of the remote sensing data shall be made in coordination with filed observations and field data. In this work contours are drawn using the spot level data extracted from the google earth image using GIS and CAD software. From the contours, DEMs are created and referred during alignment planning. Remote sensing plays a significant role in highway alignment planning, as the remote sensing data can be used as spatial data in GIS environment. As the Geographical Information System (GIS) facilitates the combined analysis of spatial and attribute data, its techniques can be utilized in the road planning process. In the process of obtaining optimum route alignment which is economical, suitable and compatible with the environment, numerous data are to be considered simultaneously (a). In this kind of circumstances GIS can be used to handle and analyse huge data in the digital environment using computers. In this work remote sensing images mainly google earth images are used to examine the study area using GIS techniques. Digitized topo maps are also used to study the contours and slope details of the terrain. GIS application not only saves time but also gives opportunity to select the best among the alternatives. Remote sensing techniques are also very much helpful in this task as satellite images will enhance the information content and give desired first-hand information of the project location.Evolving an alignment with utmost safety and economical construction and operating cost would be a prime objective in ghat road construction. As far as safety is concerned, it should get first priority as it is interlinked with road geometry and cost factor shall not have any implications over it **(Paola et al 2012).**

Nowadays the concern for environmental degradation has taken momentum and it is necessary to take care for this in all aspects. Use of locally available materials with native techniques in the construction would considerably reduce the environmental damages during the construction stage. It is also important to safeguard the local flora and fauna from the intruders due to the road construction. Ultimately the road should not give any unpleasant and unsafe sensation to the road users. Therefore, the planning shall have concerns over safety and environmental degradations apart from economical thoughts. It is important to follow relevant codes and guidelines stipulated in the country or region while forming hill roads. In India, Indian Roads Congress has stipulated many codes related to survey, planning, design and construction of hill roads. Those codes give clear guidelines and procedures to follow in all the above aspects so as to make the road safe and economical to construct and use. They broadly cover aspects of right of way, width of carriageway, geometrics such as horizontal and vertical alignments, hairpin bends, gradient, sight distances, camber, protective works and cross drainage requirements such as longitudinal and cross drainages. They also stipulate certain guidelines regarding the provisions of signages and road markings in hill roads. As the cost involved in the construction of protective works is huge in case of hill roads, it is advisable to study alternatives and use local materials and manpower in this task to reduce it. While planning the alignment, this point shall get due consideration and the alignment should be taken through the stretches where the requirement of protective works are comparatively less. Here versatility of GPS and GIS can be used to select the suitable one from huge data of alternatives to reduce such hazards **(Shaban et al 2001).**

Advanced technologies such as Remote Sensing and GIS are also useful to study the geology of the area where we plan to construct the road. High resolution aerial photographs can be used to identify rocks, faults and other geological features, not suitable for road formation. Further, these techniques are useful to find land use pattern, land type, plantation areas, drainages and deep valleys so as to incorporate them in road alignment planning. Landslides are major concern in hill roads and the areas prone to landslide shall be identified and the alignment should be kept away from those areas. In this aspect also aerial photographs and GIS techniques are extremely useful in the process of avoiding weak soils and geologically unsuitable surface strata. In these contexts, the practice of using modern survey methods such as GPS survey, using remote sensing data, computer applications like GIS and CADD in hill road planning will result in saving of time and cost apart from getting more precise and detailed project reports with less environmental issues.

Objective of study:

Based on the above-mentioned criteria the objectives of this research work are set as follows.

a) To effectively use Remote Sensing and GIS techniques in ghat road alignment
b) To propose road alignment in the hilly terrain using ghat tracer and GPS 6
c) To optimize cut and fill volumes in the proposed alignment
d) To suggest effective cross drainage system along the hill road alignment
e) To minimize environmental impacts due to ghat road formation

III. Conclusion and Future Enhancement:

Hill roads are susceptible to natural disaster damages like landslides, rock fall, flash floods, embankment erosion from river runoff, etc. With such occurrences becoming an annual affair, the cost of repair and rehabilitation incurred is also becoming substantial. By providing an adaptive geometric design standard on hill roads, the probability and severity of such damages can be minimized. The paper presents that few of the geometric parameters when deviated from IRC provisions can provide a sustainable solution. A dynamic approach to evaluate alternate geometric solutions shall provide a clear understanding of the severity of any problem area and give the designer the insight for taking the best technical decision. The alternative discussed in the paper has disadvantages when proposed in isolation or in combination with other factors, which need to be considered by the designer. The paper considers the geometric design of hill roads affected by heavy rainfall during monsoon. Further study can be carried out in same direction for hill 1 roads in snow clad areas.

1. Summary of the work done:

This paper presents the hill road construction methodology, problem, design and specification as per the IRC code for the hill road that is given in IRC: SP: 52.

First of all, the needs of road connectivity importance of the hill road and the process of road formation is laid out. The problem that occur are also mention in the above description followed by its feasible solution in order to have a preventive measure before it gets major destruction which may lead to the loss of many life. Design specification according to the IRC code was used throughout the process. Various materials used for the construction are well study and test is done before it is use for the construction purposed. The aggregate, bitumen which play the major component in road construction is also deep analyses on the basic of availability. The study is made in order to have the knowledge of hill road consequence like major problem; future aspect prevention measure and all kind of safety are studied in the section.

After getting the proper design and standard and approval the work of construction is carried on taking care of the sustainable development for the future without damaging the present scope like excessive forest cutting, blasting, forest fire, disturbance to the ecology of the surrounding.

By the propr5e mitigation the road construction is carried on and after completion of the road constructions, testing, evaluation and validation are done in order have quality road life further more.

IV. Work Area:

The particular study was made on NH-13 (TRANS ARUNACHAL HIGHWAY PROJECT) portion of 66km length from Sagalee to Doimukh, Papum Pare district Arunachal Pradesh, 791112.

Some Gallery of the Work.

Fig: 3Information location sign board from Doimukh

Fig: 4 Work Site

Fig: 5. Survey at work site to study about the machinery.

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