16. Определение расчетной вместимости автостоянок проектируемого объекта «Строительство станции технического обслуживания автомобилей с комплексом торговых зданий и административных помещений, объектом общественного питания, мойкой на земельном участке в районе д. Дворецкая Слобода» / ООО «Организация дорожного движения – ОДД». – Минск, 2011.

17. Действующие региональные нормативы градостроительного проектирования (2009г.):

– Нижегородской области;

– Свердловской области;

– городского округа Уфа (Башкортостан);

– Ростовской области;

– Кемеровской области.

18. Основные направления государственной градостроительной политики Республики Беларусь на 2011-2015 годы, утвержденные Указом Президента Республики Беларусь от 30.08.2011 № 385.

19. Проектные предложения по совершенствованию организации движения транспорта и пешеходов в составе «Комплексная схема организации движения транспорта и пешеходов (КСОД) в центральной части г. Минска» / НПЧУП БАЭС. – Минск, 2009.

20. Комплексная схема организации движения транспорта и пешеходов (КСОД) в центральной части г. Минска / УП «Минскградо». – Минск, 2009.

21. Научно-исследовательский отчет по теме «Исследование состояния стоянок на улично-дорожной сети административных районов г. Минска» / НПЧУП БАЭС. – Минск, 2002.

22. Концепция размещения мест постоянного и временного хранения автомобилей на территории г. Минска / УП «Минскградо». – Минск, 2008.

УДК-625.7

УЧЕТ РЕЛЬЕФНЫХ И КЛИМАТИЧЕСКИХ ОСОБЕННОСТЕЙ РЕСПУБЛИКИ НЕПАЛ ПРИ ПРОЕКТИРОВАНИИ АВТОМОБИЛЬНЫХ ДОРОГ

CONSIDERATION OF RELIEF AND CLIMATIC FEATURES IN DESIGN OF ROADS IN NEPAL

Кришна Чакхун, аспирант
(Белорусский национальный технический университет)
Krishna Chakhun, Aspirant (Belarusian national technical university)

Аннотация. *Статья содержит краткое описание рельефа и климатических особенностей Непала. Страна весьма разнообразная по рельефу, в*

основном холмистой местности и такими особенностями климатических условий, как муссонные затяжные дожди, имеет много задач на пути развития автомобильных дорог. Статья освещает, как эти особенности учитываются в проектировании и строительстве дорог в Непале. Это также актуально для стран, расположенных вдоль горного хребта Хиндкуш (Hindkush).

Abstract. *The article contains brief description about the relief and climatic features of Nepal. The country with varied features, but largely hilly terrain and monsoon climatic conditions with heavy rainfalls, possesses a big challenge in road development. The article highlights how these features are accommodated in design and construction of the roads in Nepal. This is also relevant to the countries along the Hindkush mountain range.*

Введение

A talk on relief of Nepal straight away leads to the picturesque view of the highest peak of the world - Mount Everest and many other beautiful Himalayan peaks which attracts thousands of tourists into the country every year. These mountains are sheltered by thousands of various species of flora and fauna – from a common to the rarest. These mountains generate thousands of freshwater rivers – Himalayan snow melt, hundreds of glacier lakes, underground water sources, surface run off from the heavy monsoon rains. The rapid mountain rivers can generate thousands of mega-watts of hydro power.

The 83 % of the country's landscape is covered with multiple young fold mountains ranging from low sub-tropic Churiya hills in the south to Himalayas. Only 17 % of the territory at the southern belt is plain area and is called Terai. A few large valleys like Kathmandu, Pokhara, Dang and others with relatively plain terrain are situated in between the mid-hills called Mahabharat range. Within a span of about 150km to 200km, the altitude ranges from 60m above mean sea level in the south to 8848m in the north, resulting in a landscape with average south facing slope of 5 %.

The high mountains block the rain bearing monsoon winds blowing from the south and cause heavy rainfall (2500 to 5000mm in places), about 90 % of which falls within 3 months (Mid June – Mid September). Melting snow and heavy down pour along the steep slopes generate numerous snow fed perennial to seasonal rivers.

Due to tectonic plate movement towards north against the Tibetan plateau, the mountains in Nepal have multiple folds and are known as young fold mountains. The slopes are fragile causing regular slips and landslides in wet season. Fast gushing hilly rivers scour its path and carry plenty of bed loads, which are gradually deposited on its course towards south. In southern planes the rivers

lose its velocity and deposit finer particles of bed load along their courses. Consequently the rivers become shallow but wider.

Country is spread east-west. Accordingly population distribution and focal points like administrative centers, economic centers and others are spread all over the country. Population density on the south is heavier and it gets thinner as it goes northwards. Similarly eastern region is dense compared to the mid and far western regions. As the capital city Kathmandu is situated almost at the center of the country, between east-west and north-south, the most of the traffic movements tend towards Kathmandu from each corners of the country. A general feature of movement between hills to hills is – from the hills down to southern plains, secondly travels along the plains and thirdly turns north towards destination. So general layout of the strategic road network is – trunk road east-west, and feeder roads connect north-south. The local road network connects the local places with the strategic roads.

The rivers and streams flow from the north to south and all rivers fall within the catchment of Ganges River in India. Nepal has basically three large river basins– in the east – Sapta Koshi with catchment area measured at the foot hill (Chatara) 54,100 km^2; Narayani (Gandaki) River in the Middle with catchment area (at Devighat) 31,100km^2; and the third is Karnali River in the mid-west with catchment area 42,890km^2 at Chisapani. In between there are number of several smaller rivers those flow across the border into Indian territory.

The mountainous landscape and altitude difference between places complicate the road geometry. In plains, length of road between the two points can be estimated from the horizontal distance between them. But in the hills the altitude difference determines the minimum road length calculated from the permissible vertical gradient, and then add the horizontal distance if required.

As mentioned above the hills are fragile, on top of that heavy rainfall in monsoon increases the risk of slips and landslides significantly. To mitigate such risks the design needs to address stability issues much more than in normal cases of plain terrain.

With such physical features, building of road network in Nepal is an excessively difficult task. The above said features tell the fact that in design and construction of roads in Nepal, the existing relief has to be taken into account and the standards for hills should differ from that with the plains to a certain degree.

Consideration of Relief in Nepal Road Standards (2007)

The Nepal Road Standards (NRS) have classified terrain according to the hill slope across road alignment.

Based on the above classification, the NRS has fixed design standards for individual terrain types. It would not be possible to discuss all details in this article, but some parameters are presented below:

Table 1 – Terrain Classification

S.No.	Terrain Type	Percentage of Cross Slope	Degree
1	Plain	0–10	0 – 5,7°
2	Rolling	> 10–25	> 5,7° – 14°
3	Mountainous	>25–60	> 14° – 31°
4	Steep	>60	> 31°

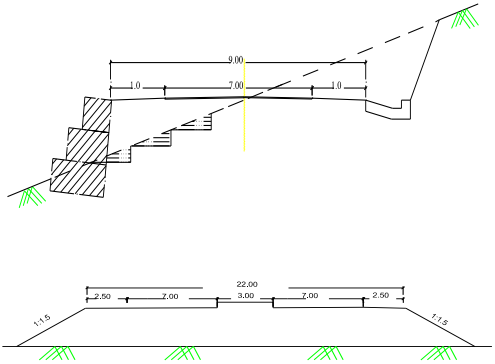
Table 2 – Capacity for Different Types of Roads

Capacity in both direction		Category			
		Plain	Rolling	Mountainous	Steep
Two Lane Blacktopped (7.0 m)	Vehicle per hour	750	500	350	250
	Vehicle per day	7,500	5,000	3,500	2500
	PCU per day	1,5000	10,000	7,000	5,000

As far as the road sections are concerned, plain terrain does not have any issues, but in hill slopes, wider the widths more the earthworks as well as retaining structures. This has been taken into account by NRS.

Table 3 – Shoulder and Formation (Roadway) Widths

Road Type	Carriageway Surface	Shoulder Width, m			
		Plain	Rolling	Mountainous	Steep
Shoulder width of Two Lane Highway	Blacktop	3,0	1,5	1,0	1,0
Formation width Two Lane Highway	Blacktop	13,0	10,0	9,0	9,0



Pic. 1 – Typical Road Cross Sections in Hills and Plains

Table 4 – Recommended Vertical Gradients

SN	Design Standard	Highway			Feeder Road		
		Plain	Rolling	Mountainous / Steep	Plain	Rolling	Mountainous / Steep
1	Maximum Average Gradient, %	3	4	5	5	6	6
2	Rise of Elevation Over 2 km Distance, m	–	–	100	–	–	120
3	Maximum Gradient, %	5	6	9	7	8	10
4	Exceptional Gradient, %	–	–	10	–	–	12
5	Maximum Length of Grade in Excess of 7 % and up to Maximum Gradient at a Time	–	–	150 m	–	300 m	300 m
6	Minimum Length of Recovery at Grade Specified	600 @2 %	300 @2%	210 @3%	300@ 2%	150 @3%	150 @4%
7	Maximum gradient at bridge approach, %	5	5	6	5	5	6

Hairpin Bend is specific to hill roads, which is required for gaining or losing the altitude in a small stretch of stable hill slope. The NRS suggests avoiding such bends, if possible, otherwise to adopt the following design criteria for hair-pin bend design:

Table 5 – Hairpin Bend Design Criteria

SN	Design Standard	Highway	Feeder Roads
1	Design Speed, Km/hr	20	15
2	Minimum Spacing Between Hairpin Bends, m	200	100
3	Maximum Gradient (%)	3.5	4
4	Minimum Gradient (%)	0.5	0.5
5	Maximum Superelevation (%)	7	7
6	Minimum Radius of Curve	14	12.5
7	Minimum Roadway Width at Apex, m		
	Two Lane	11.5	11.5
	Single Lane	9	7.5

Design speed suggested in the Road Design Manual

Table 6 – Design Speed

Terrain	Design Speed, Km/hr	
	Highway	Feeder Road
Plain	80 / max 100	60
Rolling	60	50
Mountainous	50	max 40
Steep	40	max 30

According to the standards: *minimum gradient on hill road shall be 0.5 % to facilitate better drainage; the gradients shall be eased by 1 % for every 1000 m above mean sea level; exceptional gradient should be adopted only in very difficult places and unstable locations in short lengths (maximum 100 m) in mountainous and steep terrain. Successive stretches should be separated by minimum length of 150 m with recovery grade of 3 %.*

However, in practice, observing all the above standards seemingly very difficult and many exceptions are met every now and then. These parameters are closely related with the road safety. In many cases stopping sight distance (SSF) at hill road bends can be found compromised due to steep slope involving larger earth as well as protection works. So in such case drivers rely on horns to warn an oncoming vehicle. No wonder why many fatal accidents are involved at such bends. This needs a serious attention.

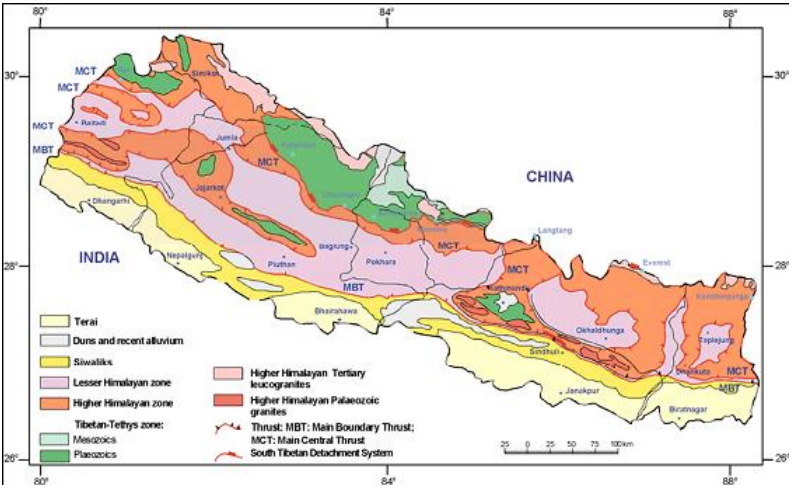
Slope Stability

Slope stability is a major concern related particularly to the hilly or mountainous terrain. In the experiences of Nepalese hill roads, landslide has been a common phenomenon, as if it is bound to occur. The fragile hill slopes under tend to slide – might be due to rain, earthquakes or tectonic movements or combined. Therefore slope stability is a major aspect in design and construction of the roads in hilly or mountainous terrain. The following picture illustrates the terrain geology of Nepal.

Under Department for International Development (DFID), UK a project 'Landslide Risk Assessment in the Rural Access Sector' has been undertaken. Landslides represent a serious problem in most mountainous areas, causing damage to roads, buildings and other structures, and disrupting the activities of the local people threatening the lives. DFID's project report has quoted that on average over 300 people are killed by landslides each year in Nepal alone, and there is some evidence that the numbers are increasing each year. Clearly therefore it is necessary for planners and engineers to do all that is possible to minimise the impact of landslides on infrastructure and the community.

Undoubtedly, road construction activity has been rapidly increasing; DFID report correctly suggests that reduction of landslide effects should be on the high

priority. Correct alignments, appropriate engineering measures, good land management practices could be the measures to prevent or mitigate the negative effects.



Pic. 2 **–** Terrain Geology

Source: Mid Hill Highway DPR

In the plain terrain roads can be mapped and built in any direction, but on hilly or mountainous regions, a road cannot be a simple line on a map – apart from the social, it has significant engineering aspect to be considered.

A key task of hill road alignment is identifying the most stable corridors and it requires information on the existing and potential landslides and their risk. One of the tools for landslide hazard and risk mapping could be the use of Remote Sensing. This is an expensive tool, may surpass the costs of individual projects. However, comparing that to the potential loses, the government should plan for its global use and prepare the mapping for all regions.

Drainage

One of the key protective measures against landslides in hills is proper drainage. The proper drainage system would lead to a long-term stability of the alignment, drainage instability (channel bed incision and bank erosion) can have adverse effects on slope stability.

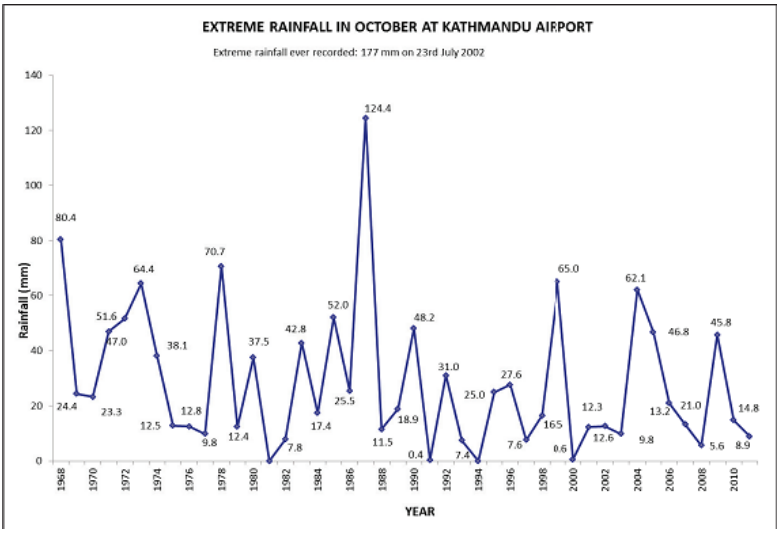
Due to the heavy rains during the 3 months monsoon period, many areas in the plains remain flooded. The peak flow outweighs the capacity of the existing river sections. Thus, the drainage in plains has a different significance. Road embankments have to be higher than the flood levels. Cross drainage structures and bridg-

es have to account for the highest flood in a defined return period. The return periods are defined depending upon the types and importance of the structures.

Climatic Conditions

Nepal lies in monsoon climatic zone and summer rain is its main phenomena. The Department of Hydrology and Meteorology (DIHM), Nepal has established meteorological stations in different parts of the country. A brief count is as follows:

Existing meteorological stations – 281;
Closed met. stations – 81.
The existing stations:
Aeronautical – 6;
Agrometeorology – 21;
Climatology – 72;
Precipitation – 173;
Synoptic – 9.
Closed stations:
Agrometeorology – 6;
Climatology – 22;
Precipitation – 41;
Synoptic – 1;
Others – 11.



Pic. 3 – A rainfall record at Kathmandu, DIHM

Table 7 – Some of the extreme rainfall ad temperature recorded

Meteorological Station at	Precipitation, mm	Date	Temperature (between 1981 – 2010), C			
	Mm	Date	Max	Month	Min	Month
Biratnagar (Eastern Terai)	405	02.07.74	33.9	Apr	9.0	Jan
Kathmandu Airport	177	23.07.02	29.1	Jun	2.4	Jan
Pokhara (Western mid hills)	357	18.08.01	30.6	Jun	7.1	Jan
Surkhet (Mid -western hills)	375.9	21.07.63	33.9	Jun	5.4	Jan
Dhangadhi (Far western Terai)	267	11.09.83	37.2	May	7.1	Jan
Dadeldhura (Far-western hills)	226.2	18.08.09	26.1	May	4.1	Jan
Jumla (mid -western high hill	206.8	14.09.75	37.4	May	-5	Jan

The recent rain fall in 2013 has surpassed above figures in some parts of the far-west and mid-western areas. Those are not mentioned here, however, the objective of these figures is to give a feel of the dire situation prevailing in Nepal.

As far as the temperatures are concerned, Himalayas, above 5000 m is remain sub-zero all-round the year. But no constructions take place in such territories. According to the landscape the climatic condition vary from south tropical/subtropical to tundra in the far north. However, the territories in terms of road construction fall within an altitude of around 3000m. So there are no situation where road remains under sub-zero condition for longer than a night or so.

Conclusion

Undoubtedly the relief plays a big role in design of the roads not only in Nepal. Particularly in case of Nepal, it has a bigger significance as hills and mountains cover 83 % of the territory and that has a bigger impact on the road development. On the other hand the 17 % of territory in Terai plains live nearly 60 % of the population. Therefore, the road network in this area has more significance. Only the difference is that, from a road design and construction point of view, road construction in plains is much easier and can align in any direction. But in hills that is not the case. Slope stability is the most important aspect and selection of a stable road corridor play key role on the life of the road.

In any case the design must take the relief and climatic conditions into full account. In case of Nepal there have been cases where not all standards have been met and a number of exceptions were allowed. This is mostly due to either due to lack of resources, or roads of a temporary nature or at an initial stage of road building. Whatever is done it has a direct relation to the safety of roads and road users, and even threats to population beyond the earth works or drainage of roads, for instance – cases where landslides are triggered by the road excavations or poor drainage.

The Nepalese Design Standards have sufficiently incorporated the concerns related to the relief and climatic conditions. However, there always remains scope of improvement, taking experiences from analytic and practical exercises. The requirements and measures have to be regularly reviewed, and explored in line with the development take places in the world.

Literature

1. Nepal Road Standard 2007, Department of Roads, Nepal
2. Design Manual Roads and Bridges, 2007, Department of Roads, Nepal
3. Puspalal (Mid-Hill) Highway Project, DPR, 2011, Department of Roads, Nepal
4. Meteorological data published by Department of Hydrology and Meteorology, Nepal
5. Landslide Risk Assessment in the Rural Sector - Guidelines on best practice – Scott Wilson for DFID, 2003
6. Design Guidelines for Rural Roads – DOLIDAR, Nepal
7. IFRTD News Letter

УДК-625.7

УЧЕТ ТРЕБОВАНИЙ БЕЗОПАСНОСТИ ДОРОЖНОГО ДВИЖЕНИЯ ПРИ РАЗРАБОТКЕ СТРАТЕГИИ РАЗВИТИЯ СТРОИТЕЛЬСТВА ДОРОГ В НЕПАЛЕ
CONSIDERATION OF ROAD SAFETY REQUIREMENTS IN ROAD DEVELOPMENT STRATEGY IN NEPAL

Кришна Чаккун, аспирант
(Белорусский национальный технический университет)
Krishna Chakhun, Aspirant (Belarusian national technical university)

Аннотация. *Статья содержит краткое описание условий требований безопасности дорожного движения и их проблемы в Непале. Ситуация в стране с дорожной безопасностью стоит довольно остро и является большой проблемой для сведения к минимуму дорожных инцидентов. Статья освещает, как требования безопасности учитываются в дорожной строительной деятельности в Непале.*

Abstract. *The article contains brief description on the account of road safety requirements and its concerns in Nepal. The country's road safety situation has been degrading and is a big challenge to minimise the incidents. The article highlights how the safety requirements are accommodated in the road construction activities in Nepal.*