

SURVEY AND DESIGN

FUNCTION OF ROAD

As already previously mentioned, the road has the principal objective of interlinking as many village centres as possible enroute from Lamosangu to Jiri, thus best serving the majority of the population of the region. According to the "Nepal Road Standard" it is classified as Feeder Road, Class II.

TRAFFIC ASSUMPTIONS AND ROAD DIMENSIONS

Assumptions

- o Road Service life: 20 years
- o Traffic volume: 10 trucks per day and direction (the magnesite mine traffic on the section Lamosangu - Kharidhunga)

hunga was considered accordingly, whereas a reduced traffic volume was calculated for the last road section from Tama Kosi to Jiri)

- o Traffic increment: 5% /year

An overloading of the trucks of approximately 50% as well as the narrow road width was taken into consideration for the dimensioning of the road base.

Dimensioning of Road Base

On average, the soil tests conducted along the road have given a CBR value of 10 % . In extreme cases, this value dropped down to 4% . Therefore, the road base has been dimensioned as follows:

- o Section Lamosangu - Kharidhunga:



Plate 5: 20 cm thick stone soling layer on the subgrade.

- 2 gravel layers of total 26 cm thickness
- 1 blacktop layer of 5 cm thickness

o Section Kharidhunga - Tama Kosi:

- 2 gravel layers of total 26 cm thickness
- 1 blacktop layer of 3.5 cm thickness

o Section Tama Kosi - Jiri:

- 2 gravel layers of total 22 cm thickness
- 1 blacktop layer of 5 cm thickness

At the beginning only sections with a CBR value of less than 10% got a stone soling under layer of 15-20 cm thickness. Later on, from km 35 onwards, this stone soling was added throughout to avoid the penetration of the generally silty sub-grade material (during wet weather conditions) into the road base, thus weakening the bearing capacity and therefore, its service life. (Plate 5).

ENGINEERING STANDARDS

Normally, if the purpose or the function of a road is fixed, the engineering standards are also given and can be picked out of the Road Standard of the concerned country. In our case, the following standards were applied:

Road Base Standard Section

(See Fig: 5).

- Design speed : 30 kms/hr
- Formation width : 5.70 - 6.10 m
- Pavement width : 2.90 m* (widening for bends)
- Bridge width : 3.50 m
- Gradient
 - . longitudinal max. : 12%
 - . longitudinal avg. : 7%
 - . longitudinal min. : 1%
 - . cross fall : 4% (always towards ms)
- Minimum radius
 - . normal curves : 10 m*
 - . hairpin bends : 8.50 m
- Slope inclinations
 - . normal (ms) : 1:1 (pure soil)
 - . maximum (ms) : 4:1 (rock)
 - . embankments (vs) : 2:3
 - . maximum (vs) : 4:5 (plus planting)
- load capacity of bridges : HS 20-44

* The pavement width of 2.90 m does not conform to Nepal's Road Standard (3.50 m) and was chosen for investment saving reasons only. The same is valid for the minimum radius of bends (15 m). Here, the reason is the sometimes very steep and rugged terrain which forced this solution.

CHOICE OF ALIGNMENT

Basic Considerations

Due to the very difficult natural preconditions in the hills of Nepal the choice of alignment should be made very carefully to find the best alternative in terms of the road's function, safety for traffic, its service life, influence on the environment, and its economy (construction and maintenance cost).

Mistakes in the choice of alignment can have enormous impact on the construction and maintenance cost because, once the construction has started, alignment changes are normally no longer possible and the engineer is forced to save the situation by the application of complicated and expensive construction measures which are always followed by higher maintenance cost. Therefore, only well trained and widely experienced specialists like geologists, geotechnicians, road engineers, and structure engineers should be assigned to this challenging task. They should be given enough time to conduct the necessary exhaustive survey and investigation of the road region. (See Fig: 6).

Accurate maps and aerial photographs of proper scale are indispensable instruments for their support. The more accurate these instruments are, the less time in the field is consumed by the survey team. In the case of the LJRP, we had maps of a scale of 1:5,000 with contour line intervals of 5 m along a large enough corridor of the proposed general alignment according to the feasibility study. These maps allowed the finding out of all possible alignment alternatives in the office in a minimum of time. For the evaluation of these alternatives they had to be verified in the field. A more advanced method to reduce field work, at least for the bigger part of the survey team (except the geologist), is the drawing of a special map, the "Potential Risks Map", which discloses the areas of potential land movement risks (rockslides, landslides and slumps) and is a very helpful instrument for the road engineer to reduce his possible alignment alternatives to the technically feasible ones only.

In general, the most economic solution is the alignment with the shortest possible distance between two points. For the hills of Nepal this is very often not the case. A longer detour of alignment to avoid a difficult or unstable patch of terrain can be immediately economical during construction or compensated in the future with less maintenance. Therefore, areas with a deep blanket of loose soil (Plate 6), water saturated zones, areas with traces of old slides and new slides (Plate 4), and terrain where the rock strata falls with the slope should be avoided if at all possible.

At this point it may be mentioned that in some places a narrow jeepable or truckable road with a technically unsound alignment may exist which could be widened. In such cases it is more beneficial to completely disregard previous investments and select a better alignment. In other words: "Don't let good money run after wasted money"!

Fitting of Alignment into the Terrain

As soon as the best alternative of alignment is found the centre line has to be fixed in the terrain very carefully. Again, the main problem will be the dubious stability of the slopes. Therefore, these slopes should be touched as little as possible to avoid slides. In other words, the alignment should be adapted according to the constraints of the terrain by having curve radii according to the contour lines (or close to them) and by narrowing the road width to a reasonable degree along very steep terrain. Obviously, such an alignment does not need huge and costly structures. From the view point of existing low traffic and desirable speed, one-lane roads with passing places at appropriate distances and a design speed of not more than 30 kms/hr will be sufficient in hilly areas in general. Such a standard is also justified by the fact that trucks are normally heavily overloaded and can move upwards not faster than

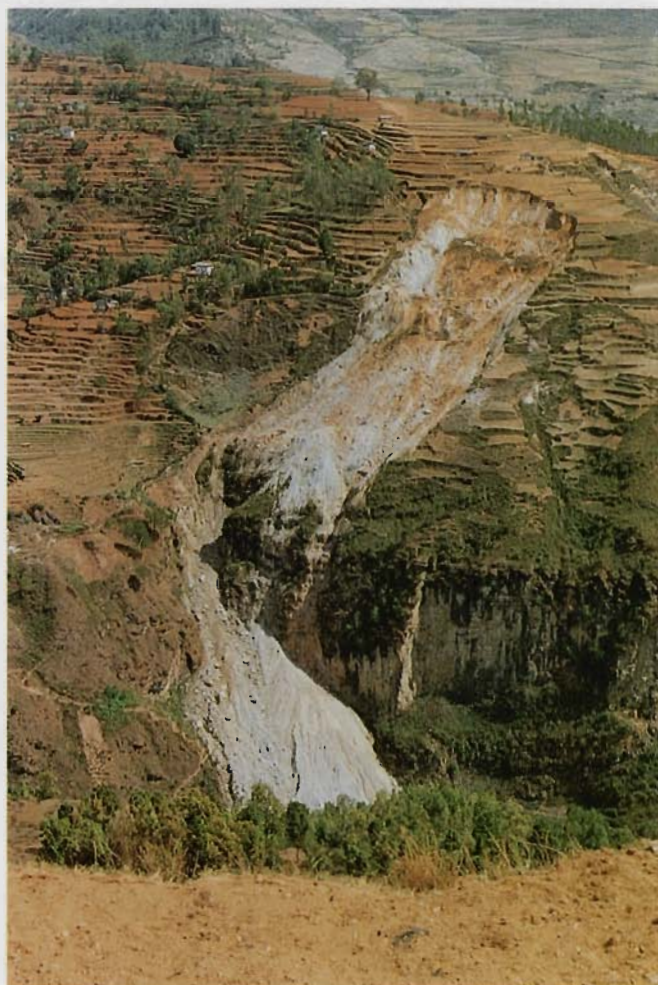


Plate 6: In the zone of the slide the loose soil cover amounts to approximately 20 m thickness.



Plate 7: The slope of this road section is so steep that a retaining wall on the vs and a toewall on the ms were constructed.

5-10 kms/hr and should drive downwards also not faster than 30 kms/hr because of safety reasons (brake failures).

In general, the road profile should not entirely be cut into the slope because it interferes with the slope stability by cutting away the slope toe and will produce slides. Therefore, a road profile which is only cut half into the slope is the most appropriate solution in terms of environmental considerations as well as long term investment (slightly increased construction cost, but drastically reduced maintenance cost). Another advantage of this solution lies in the tremendously reduced amount of surplus material vis-a-vis the fully cut out road profile or even in a full mass balance (Fig. 7).

Fixing of Centre Line in Slope

In the case of the LJRP, the first steep ascent from the Sun Kosi Bridge to Chhap (see Plate on cover) was designed and constructed by cutting the entire road profile into the slope; a method which is applied nearly everywhere in the hills of Nepal and which seems to be safe enough because, if slides occur, they do not affect the road structure as such but only the ms

slopes which can be easily cleared over the road edge down the slope.

When construction started problems arose concerning surplus material. Safe deposit places were rare and transport had to be drastically limited due to lack of facilities (only possible on porter back). What else was there to do than throw it down the slope? By doing so the whole vegetation below the road was destroyed, thus weakening the slope stability. During the first monsoon the result of this construction method became obvious: at many places slides occurred. The undercut ms slopes failed above the road and the loose soil deposits below the road slid down as well. The road itself did stay in place. The repair of the damage and the improvements undertaken along this section swallowed up a considerable amount of money and forced us to reassess the situation. There was no other choice than to accept the lesson and change the design guideline concerning the location of centre line in the slope. Henceforth, the centre line was fixed in general according to Fig. 7.

Very often, where the slope is too steep to allow a safe natural slope inclination, retaining walls on the vs and toewalls on the ms are needed (Plate 7).

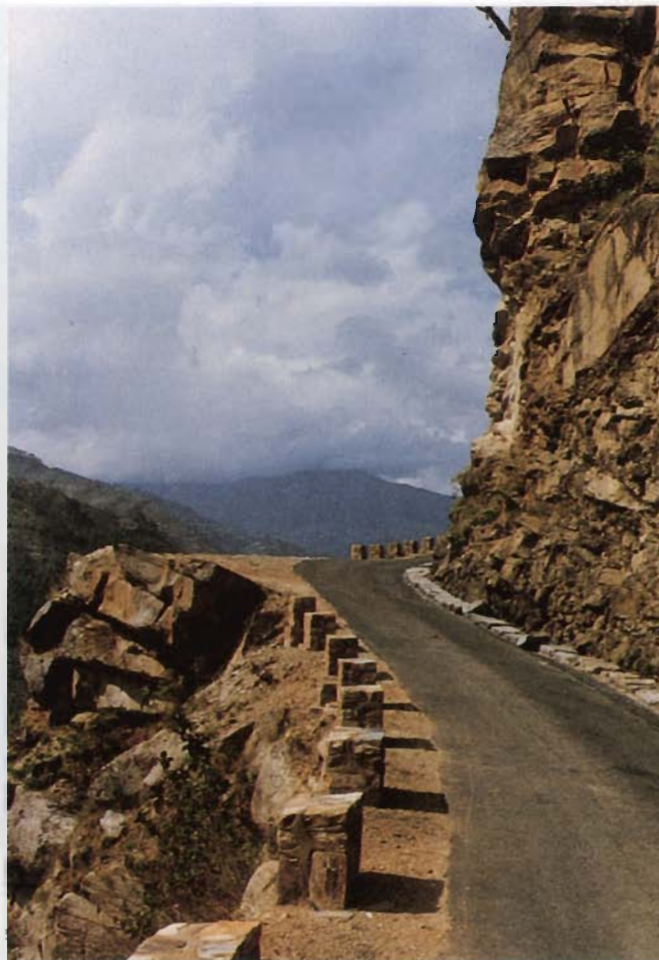


Plate 8: The whole road profile is cut into the sound rock.

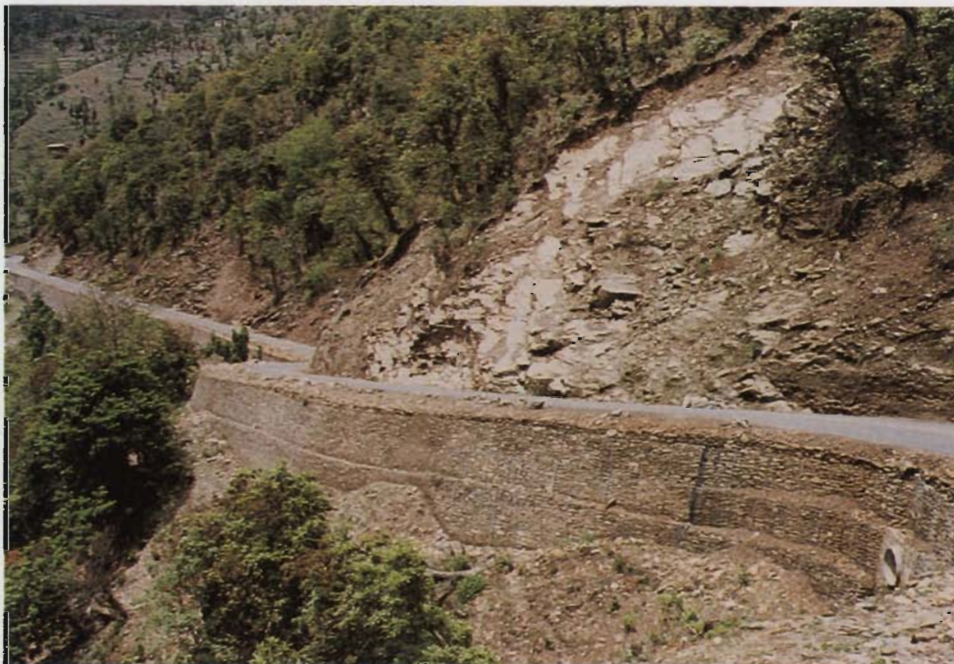


Plate 9: Negligible cut on the ms (left half of road section), entire road profile supported by vs retaining wall.



Plate 10: Cut and fill balance in the long section.

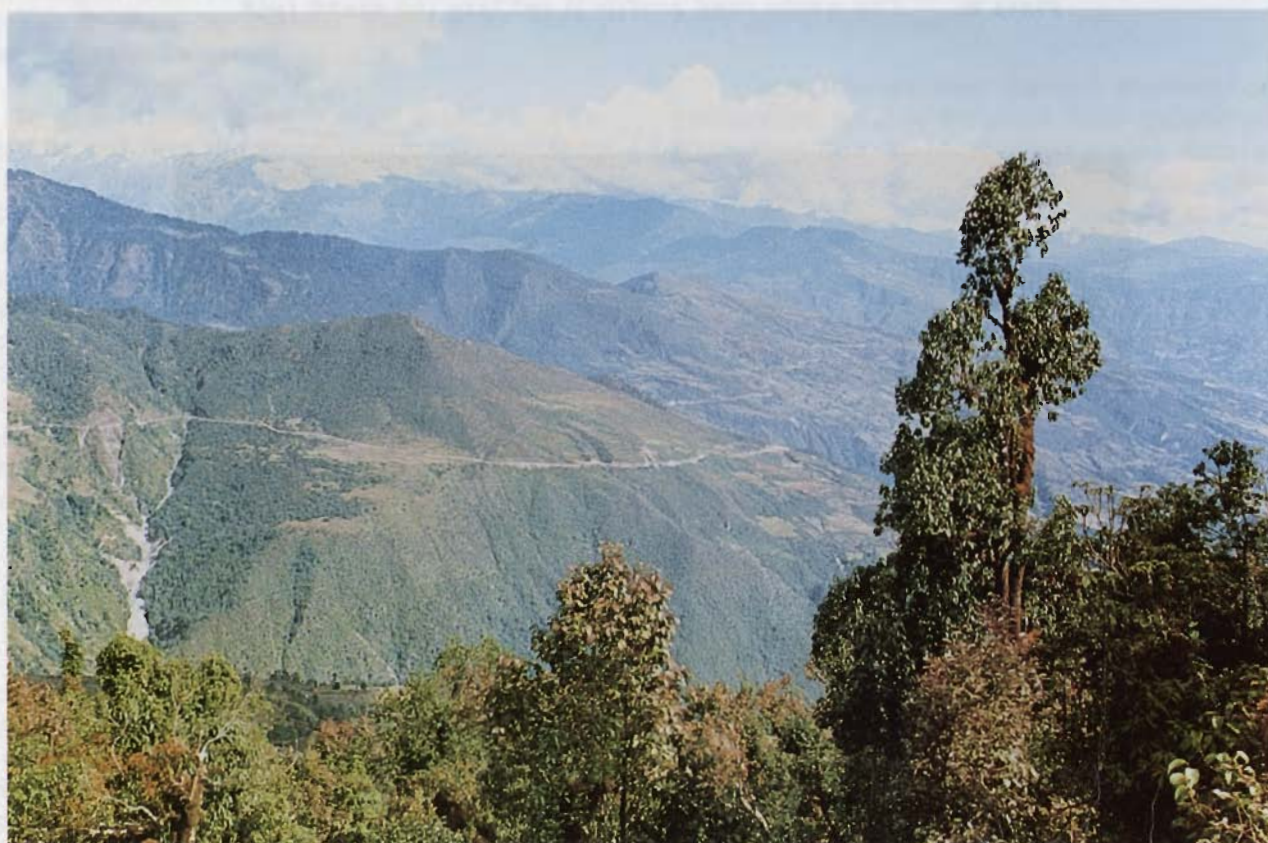


Plate 11: The road section between Kharidhunga Pass and Hanumante Pass.



Plate 12: The Jiri valley is reached after a drive of 188 kms from Kathmandu (See Fig: 8).

In exceptional cases, where the slope stability is guaranteed (sound rock), the road profile can be cut fully into the slope (Plate 8).

In cases where the slope stability is doubtful the centre line has to be shifted to the vs so that the slope may not be cut and the entire road rests on a vs retaining wall (Plate 9).

In general, there will always be a certain surplus of excavation material along the construction site. If no safe deposit places are available and the material is of appropriate quality, it can be used for embankments by shifting the centre line to the vs where the slope conditions allow it (Plate 10).

GENERAL DESCRIPTION OF ALIGNMENT

Closely following the project's objectives, such as linking as many villages as possible and avoiding valley floors or lower parts of slopes, the finally selected alignment did differ from that of the feasibility study to some extent:

- o Complete change of alignment between Nigale (km 27) and Kirantichap (km

65) where it was shifted out of the Halaule Khola and Charnawati Khola valley floors upwards and now directly connect the magnesite mine at Kharidhunga and Charikot (District Head-quarter of the Dolakha District). The new alignment became approximately 10 kms longer.

- o Shifting of the Tama Kosi crossing point river-downwards for approximately 1 km to be in safer geological conditions along the lowest part of the adjoining valley slopes.

The final general alignment is now 110 km long and starts shortly before Lamosangu (km 78 of the Arniko-Rajmarga, Kathmandu-Kodari) at 730 m.a.s.l. (Plate 20). For the first 32 kms it climbs steeply up to the Kharidhunga Pass at 2,660 m.a.s.l. Then it descends slowly to cross Halaule Khola (2,500 m.a.s.l) and Charnawati Khola (1,885 m.a.s.l), reaches, with some ascents and descents, Charikot at 1,970 m.a.s.l (Plate 11) before it descends sharply for 17 kms down to the Tama Kosi at 845 m.a.s.l. Again, it ascends steeply for 25 kms to the Hanumante Pass (2,555 m.a.s.l.) before finally reaching the Jiri Valley (1,935 m.a.s.l) after a descent of 13 kms (Plate 12).