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International Centre for Integrated
Mountain Development

ROAD CONSTRUCTION IN THE NEPAL HIMALAYA: THE EXPERIENCE FROM THE LAMOSANGU - JIRI ROAD PROJECT

Urs Schaffner

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Kathmandu, Nepal
March, 1987

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Cover photograph: Lamosangu Bridge 750 m.a.s.l r.h. lower corner on the Arniko Highway is the starting point of the road. With 15 hairpin bends, the road climbs 500 m. up a fragile slope to reach fairly stable alignment. Photograph by the author.

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FOREWORD

Extreme difficulty of access - in varying degree of course for different parts of the mountains - is one of the dominant characteristics of mountain communities, and one of the most formidable constraints on the effective implementation of the essential programmes of progressive rural development in mountain regions. So it is throughout the hills and high mountain districts of Nepal. The building of all-weather roads through the mountains to improve access and to open remote areas to the benefits of modern technology is exceptionally costly and technically very complicated, particularly on steep and unstable slopes.

This Occasional Paper, which Urs Schaffner prepared while working as a short-term staff member of ICIMOD, describes a twelve-year task of building a 110-kilometre road through the 'fragile mountains' of the central Himalayas in Nepal. It attempts to identify and record, for the consideration of other road engineers in these mountains, the lessons of experience of this particular road project. It is not in any sense intended as an "evaluation" of this highly complex project as a whole. This would require a full assessment of social and economic factors (and objectives) well beyond the scope of this discussion which is strictly limited to the technical engineering aspects of road construction as encountered in the building of the road over the mountains from Lamosangu to Jiri over the years from 1974 to 1986.

This Himalayan task was undertaken by His Majesty's Government with very substantial capital aid and technical assistance from the Government of Switzerland. The Swiss aid project involved not only the transfer to the Himalayas of the technical knowledge of mountain road construction acquired over long experience in the Swiss Alps, but also the innovative adaptation of this engineering knowledge and experience to the special environmental (and socio-economic) conditions of the 'middle hills' of Nepal. In an understandable effort to maximise the social and economic benefits of this new mountain road, HMG Nepal and the Swiss Government extended their collaboration into a related Integrated Hill Development Project (which is separately discussed in a review of Rural Development Projects in Nepal undertaken by Mr. B. B. Pradhan and published in 1985 as ICIMOD Occasional Paper No. 2). In the lengthy process of road construction, many useful lessons were learnt by all concerned. Though this Paper is based very much on the professional judgements of one of the Swiss engineers (albeit the Swiss Project Leader who spent some eight years working on this road project in the Nepal Himalaya), the whole enterprise was very much a team effort - on an international scale. I cannot emphasise this too strongly. Above all, a very warm and special acknowledgement must surely be given to the professional contribution of the staff at all levels of His Majesty's Department of Roads - most particularly to the Chief Engineer, the Regional Engineer and the Project Management staff (all Nepalese, of course) of the Lamosangu-Jiri Road Project. Their experience of road building in the special conditions of Nepal was undoubtedly an essential ingredient in the Project's successful completion.

And, whatever the technical and managerial contribution of the project professional staff both Nepalese and Swiss, we must not forget that the road was actually built by many thousands of sturdy and hard-working Nepalese labourers, skilled and unskilled: the great majority of them hill farmers compelled by the general poverty of hill agriculture to work "off-the-farm" to earn supplementary cash incomes. Their achievement in the most difficult conditions is there for all to see and use - a spectacular mountain road that will undoubtedly provide an essential and lasting stimulus to rural progress in a hitherto inaccessible region of central Nepal.

The engineering, economic and financial issues of road construction in the mountain are fundamental to any consideration of integrated mountain development throughout the Hindu

Kush-Himalaya. Each of the sovereign States of this Region has had important practical experience in this field of mountain infrastructure - whether it be with the Karakoram Highway in Pakistan, the Phuntsoling-Thimphu road in Bhutan, the Lhasa-Kathmandu Highway across the Tibetan Plateau and through the Nepal Himalaya, or the tremendous achievements of the Border Roads Organisation throughout the Indian Himalaya. Early next year, ICIMOD will organise an international 'expert meeting' of mountain highway planners and engineers to promote the exchange across national frontiers of professional knowledge and experience of mountain road construction. In the meantime, we must express our thanks to Urs Schaffner for this particular and most useful contribution from the Nepal mountains to this international exchange.

Finally, we at ICIMOD are specially grateful to HMG Nepal Department of Roads, to the Government of Switzerland, and to the Swiss Association for Technical Assistance (SATA) in Nepal for assisting, facilitating and encouraging this ICIMOD publication, intended as a modest contribution to the welfare of all who live and work in the inaccessible hill communities of this mountain Kingdom and of its neighbours throughout the Hindu Kush-Himalaya.

Colin Rosser
Director

ACKNOWLEDGEMENTS

All the Swiss Technical Assistance personnel who worked at varying times and for varying periods on the Lamosangu-Jiri Road Project described in this ICIMOD Occasional Paper (or on the associated Integrated Hill Development Project) would wish me to express our very high appreciation of the warm, friendly and highly professional relationships that developed between the Swiss team and their Nepalese colleagues at all levels in a number of HMG Ministries. The construction of this mountain road through very rugged terrain in the middle hills of Nepal was an international working **partnership** in every sense.

I am sure that all involved, both Swiss and Nepalese, learnt a great deal about the technical and management problems of road construction in the Himalayas. The short paper that follows is an attempt to summarise the lessons learnt personally by just one of the engineers privileged to have been involved. It is hoped that it will be found useful by all engaged in similar enterprises in road building in these splendid but difficult mountains.

I must add my thanks to my friends and colleagues on the staff of HMG Nepal Department of Roads for much professional assistance, and to my former employers in the Swiss Government and SATA in Nepal for permission to publish this personal assessment of our experience with the building of the Lamosangu-Jiri Road. It is important to state that I alone am responsible for the judgements made - which do not necessarily represent the views of any government or agency. A special word of thanks must be given to Dr. Krishnakumar Panday, formerly a staff member of the IHDP Project along the Lamosangu-Jiri Road, now on the professional staff of ICIMOD, for his many helpful and knowledgeable suggestions and comments. Finally, I am grateful to Dr. Colin Rosser, Director of ICIMOD, who encouraged me to write this Paper as a contribution to the international exchange of knowledge about an important aspect of integrated mountain development here in the Hindu Kush-Himalaya.

Urs Schaffner

ABBREVIATIONS

CBR	California Bearing Ratio
DDC	Directorate of Development Cooperation
DOR	Department of Roads
HMG/N	His Majesty's Government of Nepal
IHDP	Integrated Hill Development Project
LJRP	Lamosangu-Jiri Road Project
mt	Metric Ton
ms	Mountain Side
vs	Valley Side
MWT	Ministry of Works and Transport
NC	Nepalese Currency
SATA	Swiss Association for Technical Assistance
SG	Swiss Government
WFP	World Food Programme

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INTRODUCTION

When people discuss the importance of rural road access as a precondition for an efficient development process in such areas it is not without mentioning the main shortcoming of these construction activities - substantial environmental damage - especially in the rugged hilly belt of the Hindu Kush-Himalaya region.

Having worked a couple of years in the Lamosangu-Jiri Road Project as survey/design engineer and project co-manager later on during construction, I had the rare opportunity to experience such an undertaking from the beginning to the end including all the many lessons we were taught by nature or other prevailing circumstances.

The purpose of this paper is to communicate these lessons, the reactions they provoked from our side, the difficulties and problems that had to be overcome, and the conclusions we tried to draw.

In this connection I have to say that we road builders have deserved our bad reputation as destroyers of the environment. But on the other hand, I dare to say that we could do much better, and to say the least, minimise these damages to a fraction.

This introduction should explain under which framework and rules the project was implemented in order to understand both the degree of freedom and the limitations within which we had to act. Survey and Design highlights the key role of survey and design for the success of the project in terms of economy and environmental impact. Construction deals with the construction execution with special focus on erosion control, whereas Maintenance emphasises the importance of preventive maintenance as a deciding factor for the road's life span and economy. The Summary tries to summarise the key problems and lessons and presents the findings. Some supplementary data of general interest, like project cost and construction data (Appendix I) and first visible impact of the road (Appendix II), conclude the paper.

PROJECT HISTORY

Switzerland's involvement in the development of Nepal started in the late fifties and it was in these early years that the region of Jiri was selected for first activities. These activities developed into one of the most important projects of that time: the Jiri Multipurpose Development Project which was handed over to His Majesty's Government of Nepal (HMG/N) in 1970/71.

One of the major drawbacks of this project was the lack of suitable communication and transportation facilities between the project area and the economic centres of the country. This fact led to the idea of opening up the area by a road.

HMG/N proposed to the Swiss Government (SG), represented in Nepal by the Swiss Association for Technical Assistance (SATA), to conduct a feasibility study of a road connection from the already existing Kathmandu-Kodari Highway (Arniko Rajmarga) to the Jiri region considering the near forest areas as well as the magnesite occurrence at Kharidhunga. This study was completed in 1971 and gave positive results if considerable additional development efforts for agriculture and forestry would be undertaken too. (Lit. 2) In summer 1972, HMG/N requested the SG to participate in the development efforts of the concerned hill region and in the financing of the access road.

The envisaged region contains the eastern part of Sindhupalchowk District (east of Sun Kosi River) and the whole Dolakha District which includes the Jiri area. The planned access road should start shortly before Lamosangu (km 78 of the Kathmandu - Kodari Highway) and end after 110 km in the Jiri valley (see Map 1).

The following main targets formed the basis for the planned development efforts in favour of the mentioned region:

- o Construction of an access road from Lamosangu to Jiri serving as a backbone for the success of the integrated rural development activities;

- o Improvement of agriculture and building-up of pasture and forest management on the basis of proper land use adapted to the prevailing local conditions;

- o Reduction of pressure on the available land by development of small scale and cottage industry and proper forestry;

- o Improvement of relations between population and environment by education, demonstrations, building-up of awareness and public health, as a precondition for an efficient policy of population and technical measures for erosion control.

For the implementation of this package of integrated activities the two governments formulated two complementary projects:

- o The Lamosangu-Jiri Road Project (LJRP) for the construction of the road and

- o The Integrated Hill Development Project (IHDP) for integrated rural development activities.

For the success of both projects a very close cooperation with each other was imperatively foreseen.

The time horizon for the realisation of the projects was assumed:

- o 6 years for the LJRP (1975-1981)

- o 15 years for the IHDP (1975-1990)

PROJECT FRAME AND OBJECTIVES

Project Frame

As the LJRP was the first hillroad project where HMG/N actively participated, the guiding idea for the implementation was to give the Nepalese engineers a fair chance to contribute fully to the project realisation and get maximum benefit from the applied technical know-how and expertise. Furthermore, it was intended to strengthen and improve the Nepalese administrative bodies.

Counterpart System

Therefore, the two governments decided on the already known concept of partnership (See Fig. 1: Counterpart System). This concept is based on the existing administrative rules and regulations of HMG/N and a joint decision-making process at all levels (project management and site engineers in the case of LJRP) of the Nepalese and foreign counterparts.

The two contracting parties for both the governments are:

- o The Ministry of Finance for HMG/N,

- o The Department of Foreign Affairs for the SG.

The two executing agencies are:

- o The Department of Roads (DOR) in the Ministry of Works and Transport (MWT) for HMG/N,

- o SATA for the Directorate of Development Cooperation (DDC) for the SG.

The time period for the execution of the project was fixed to be 6 years but had to be extended by another 3 years in 1980:

- o First project phase 1975 - 1980,

- o Second project phase 1980 - 1984.

The financial means were fixed at NC 94 million and increased in 1980 to NC 225 million (for reasons see Appendix I).

Objectives

The project objectives can be divided into two categories:

- o Economic, social and environmental objectives,

- o Technical objectives.

a) Economic, social and environmental objectives

- o In order to fulfill its function as an access road and serve the local population best it should link as many villages as possible on the way from Lamosangu to Jiri. Therefore, the road should mainly be located on the higher parts of the slopes where most of the villages are situated. In addition to that, it should not lead through cultivated land, if possible, in order to save this non-renewable resource (Plate 1).

- The application of labour intensive construction techniques is foreseen to contain the investments in the project region and impart technical expertise of road construction activities to the local population. Besides that, it creates considerable employment opportunities and the earned money can be used for the improvement of the living conditions of the labourers.

- As the region is a food-deficit area, the farmers should not lose the very basis of their livelihood without adequate land compensation being provided for land needed for the road construction.

- It is expected that the project will attract an enormous number of labourers from outlying regions who would not be able to return home for the night. Such a situation would create a tremendous increase in food demand on the local market, causing high inflation in consumer goods. Therefore, protective measures have to be taken by requesting the World Food Programme (WFP) for support. Under this programme the labourers are eligible to buy a fixed quantity of flour, oil and lentils for half the local market price.

Plate 1: The road links Namdu (right foreground), Maina Pokhari (centre) and Kabre (right centre) on the way to Hanumante Pass.

Plate 2: For bioengineering erosion control measures nurseries provided the needed "construction" material: project nursery at Phaphlue (km 95).

For the 2nd project phase some additional economic and environmental objectives were added:

- o To generate a maximum of income out of the total investment to the local population and to improve the training opportunities and building-up of local knowledge and infrastructure, technically easy road construction activities like earthwork must be awarded to local piece-work contractors.

- o To deal more successfully with the fragile slope properties the erosion control and protection measures have to be strongly intensified by enlarging the area of action according to need beyond the immediate road strip (Plate 2).

- o Application of bitumen emulsion as binder for blacktopping. Whereas ordinary bitumen must be applied hot, bitumen emulsion is applied cold, thus avoiding the use of firewood for heating and therefore, supporting the efforts towards maintaining ecological balance of the region by decreasing deforestation.

b) Technical objectives

- o The alignment has to be well adapted to the topographical conditions and should follow the upper parts of the slopes where they are less steep and the volume of water run-off is much lower than at valley floors (this requirement corresponds to the first one under a); (see Plate 1).

- o The road has to be constructed in such a way to minimise the construction investment and future maintenance cost.

- o On-the-job training of project staff at all levels and of labourers, in order to guarantee maximum know-how and expertise transfer.

For the 2nd project phase two more objectives were added:

- o The initially planned gravel road will be blacktopped from Lamosangu to the Tama Kosi Bridge (km 71.5) as an erosion protection measure for the road surface. A decision which corresponds to the requirement under the second point of b). Later on, the last 38.5 kms till Jiri were also blacktopped.

- o On-the-job training of piece contractors (see also the 3rd point of b).

All these objectives were binding for the execution of the project and had to be strictly observed even if it meant an increase of investment as e.g. the application of labour intensive construction techniques or a slow down of work progress by awarding earthwork contracts to piece contractors.

PROJECT ADMINISTRATION

Organisational Set-up

For the first phase of the project (1975-1980) the organisational set-up was rather complicated.

Both the governments appointed a Swiss consulting firm (Signat Ltd.) for the project realisation (general engineering services, survey, design, construction supervision, technical guidance and project management). This triangular relationship was not the best solution, as too many different interests had to be considered and the consultant had to serve several parties at the same time (Organisation Chart 1st Phase). In addition, the consultant appointed only the Swiss project co-manager whereas the Swiss site engineers were appointed directly by the DDC/SATA but were also responsible in technical matters to the consultant.

Project Organisation

For the second project phase (1980-1984) the organisational set-up was slightly changed in order to eliminate the disadvantages of the first set-up. As the advisory engineering services were mainly completed the consultant's position was changed to a back-stopping task. Therefore, all the Swiss project staff was now directly employed by DDC/SATA. Their responsibility was now to SATA/DDC and no longer to the consultant (See Fig: 2 & 3 Organisation Chart 1st and 2nd Phase).

Project Management

The Nepali manager and the Swiss co-manager were entrusted with the project management and jointly deciding as counterparts. They were responsible for the execution of the project under the rules and regulations of the DOR. Their main activities were to:

- o Coordinate and administer all internal project matters,
- o Prepare the yearly budgets,
- o Prepare and supervise the construction programmes,
- o Procure the necessary equipment and construction material,
- o Handle all technical and financial matters,
- o Prepare recommendations for contract awards,
- o Supervise the survey, design, and construction activities including the work quality.

For the execution of these tasks they were supported by administrative and technical staff operating from the head office in Kathmandu.

The survey/design was conducted by a survey/design team consisting of one or more Nepali engineers and one Swiss engineer (counterpart system). It was completed in 1978.

The road construction was supervised by 2 (1975/76) to 5 site engineer teams (1981-1983), consisting again of one Nepali assistant engineer and one Swiss resident engineer (counterpart system). During the construction peak seasons 1981/82 and 1982/83 two additional earthwork sections were opened under the piece contract system, guided by a single Nepali assistant engineer each, to respond to the much higher need of supervision for the piece work system (one contract having a size of only 20-200 m road length).

These engineer teams were supported by technical and administrative staff like overseers, supervisors, surveyors, draftsmen, storekeepers, accountants, etc. operating from their respective site offices along the road.

To respond to the strong emphasis on erosion control measures during the 2nd project phase a Swiss forest engineer was responsible for structural and bioengineering protection activities (1981-1983). He was supported by technical staff (overseers, supervisors) operating along the whole road.

During the years 1981-1984 a Swiss mechanical engineer had to improve the situation of vehicle and equipment maintenance and build up an efficient spare part management system. He, too, was supported by mechanics and operators working at our main workshop Charikot.

Special Aspects

Some few special aspects of the project administration have to be mentioned here which had a rather dominant influence on the implementation of the project. (See Fig: 4).

a) Equipment and Material Procurement

During the first phase of the project HMG/N rules and regulations were applied. This fact led to some delays in the construction programme as these rules were rather inappropriate and the decisions for procurement contract awards were not taken in time. For the second project phase it was agreed that the SG will procure through SATA all the materials and equipment from abroad, whereas for local procurements HMG/N rules and regulations remained valid.

b) Construction Contract Awards

Here too, HMG/N often did not process these contracts in time. In exceptional cases, contracts were delayed upto 1 full year causing, again, considerable delays in the construction programme and loss of money due to inflation. With the introduction of certain special regulations this situation could be improved considerably.

c) Land Compensation

HMG/N was able to pay only for the land taken along the first 4 kms within the first project phase. This shortcoming created tension between the unpaid land-owners and the project. This problem was solved when the SG agreed to pay for all the remaining land from km 4 to 110 out of the Swiss project funds if certain conditions were met (deadlines for administrative procedures).

d) WFP Support

The interest among the project labourers for this food support was very great, emphasised by the fact that many labourers disappeared from their work if the food rations were not distributed. HMG/N was responsible for the transport of the food to the project sites and its distribution to the labourers. This arrangement created many

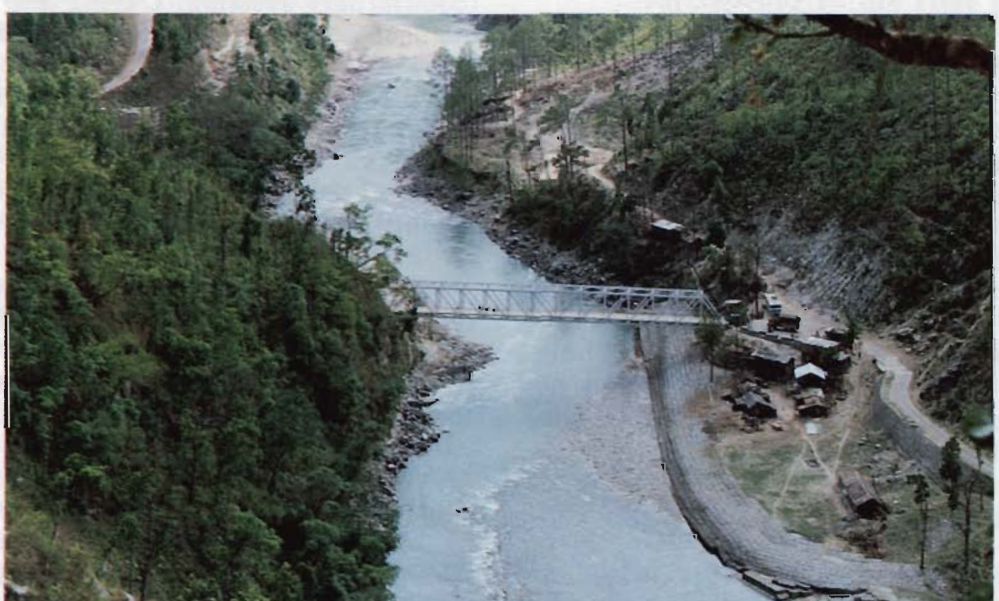


Plate 3: The road crossing the narrow Tama Kosi valley at km 71.5.

Plate 4: Deforested and slide-prone area beyond the Halaule Khola.

difficulties for our project because only about 40-50% of the foreseen food quantity could be distributed and more often than not, with considerable delay. It is evident, that this shortcoming caused delays in the construction programme and mainly affected the earthwork sections where the majority of workers were engaged.

NATURAL PRECONDITIONS

Road construction infrastructures are very much dependent on the natural preconditions. Favourable preconditions generally result in modest construction volume per km, whereas unfavourable preconditions can bring enormous work volume and be very expensive, being not only limited to the road itself but including works in the farther vicinity of the alignment (erosion control works).

In the hilly belt of Nepal the following preconditions have to be considered:

- Climate
- Geology
- Topography
- Environment

Climate

The climate in Nepal is mainly dependent on the altitude and varies from sub-tropical in the Terai to alpine and tundra in the Himalayas. The annual rainfall differs from place to place, ranging from less than 250 mm (Central Himalaya) to more than 4,000 mm (near Pokhara). Most of the precipitation occurs during the monsoon period from June to September and is concentrated in the Terai and on the Hills to the south of the Himalayas.

For the project region the temperatures rarely drop below 0°C, thus causing no frost penetration into the upper soil surface layers (frost penetration results in loss of bearing capacity of the road structure if no protection measures are taken). The precipitation varies slightly in the area but is enormous. The IHDP meteorological station at Bonch registered the maximum annual rainfall in 1985 at 3,745.6 mm over the last 7 years whereby the maximum record within 24 hours stands at 155 mm. Approximately 80% of the annual rainfall is concentrated in 4 months only, creating tremendous problems for the road builder and one can truly state that road building in the hills of Nepal is mainly a battle against water.

Geology

Nepal's mountain ranges are affected by a constant tectonic uplifting which is accompanied by a down cutting of the river systems. The result of these natural forces are slopes which become steeper and steeper and therefore unstable. This phenomenon is supported by rock of doubtful quality, being mostly soft and deeply weathered. Very often such rock surfaces are blanketed by thick masses of loose soil and boulders, thus adding to the instability of the terrain.

It is evident that such conditions make road building a difficult task.

Topography

The hilly belt of Nepal generally consists of rugged topography with tremendous differences in elevation ranging from approximately 500 m.a.s.l. to 3,500 m.a.s.l. The resulting steep slopes are divided into many gullies and small valleys and the valley floors are mostly extremely narrow (Plate 3). Such extreme conditions demand a very careful and well adapted location of the road alignment.

Environment

The local population is still largely unaware of the importance of forests and vegetation cover for a balanced ecosystem. But, on the other hand, it is mainly the strain of overpopulation which leads to a depletion of the forest reserves, by cutting of trees for firewood (the only source of energy) and the extension of farmland into too steep and unsuitable areas. Such deforested and abandoned land has an accelerated water run-off in volume as well as in speed and is prone to slides (see Plate 4). During the last ten years the project area is still increasingly threatened by deforestation and land degradation, a fact which has not only its negative influence on road construction, but also on road maintenance.

These four above mentioned natural preconditions all have a negative influence on road construction and make it on the whole very difficult to find an alignment which becomes not too costly for construction and maintenance and brings no discredit upon the environment.

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 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:

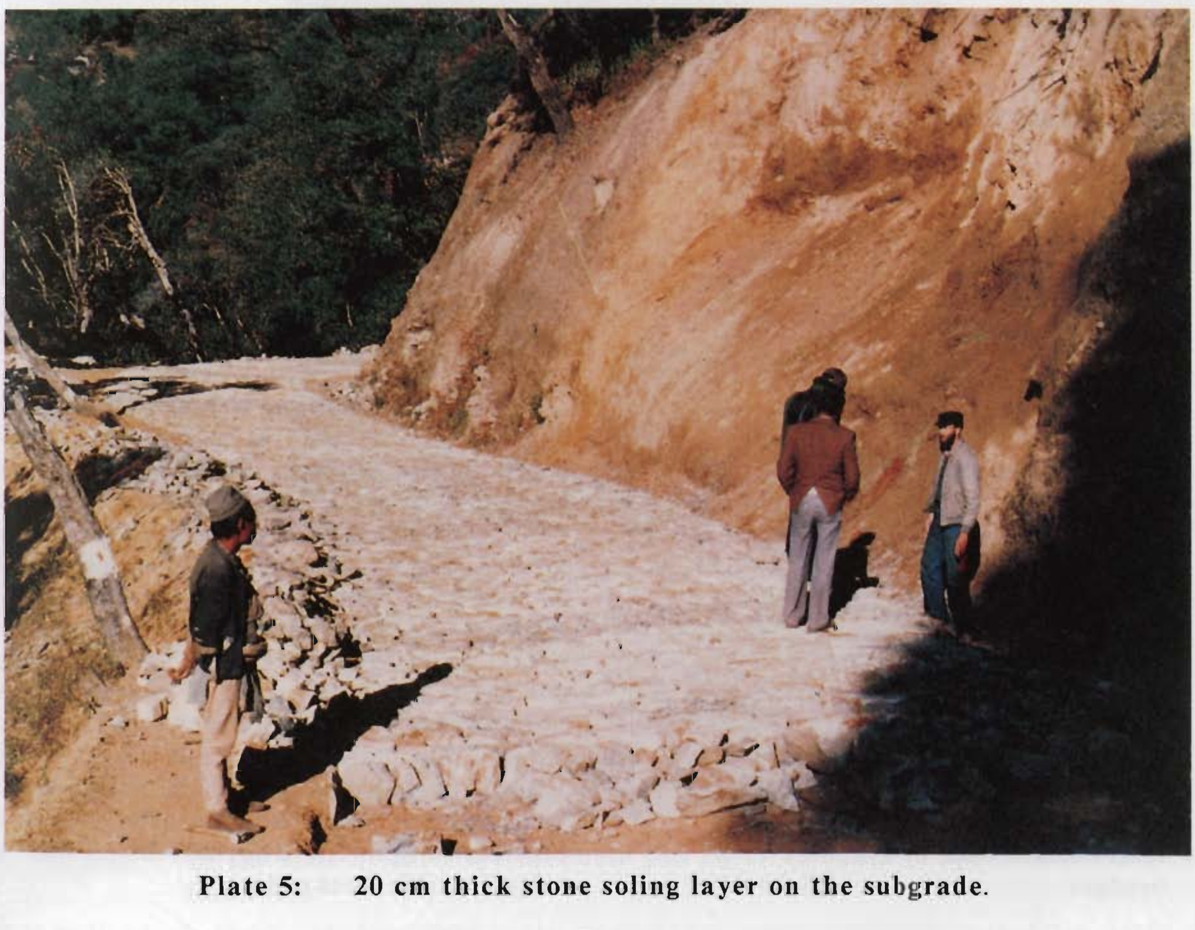


Plate 5: 20 cm thick stone soling layer on the subgrade.

- 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* (widenings 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

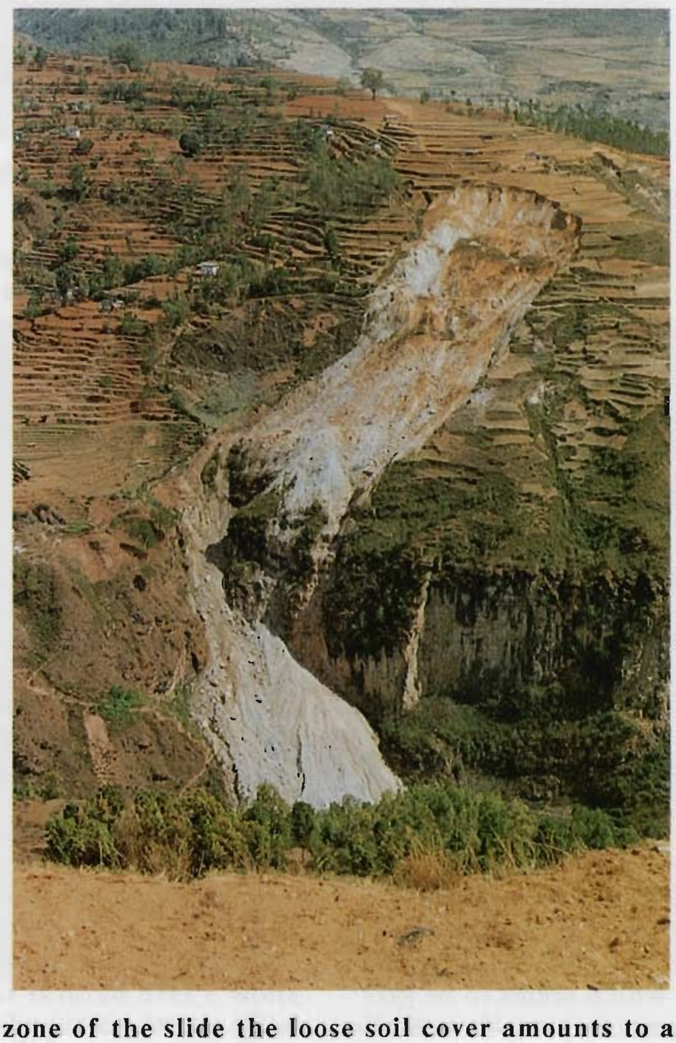


Plate 6: In the zone of the slide the loose soil cover amounts to approximately 20 m thickness.

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).

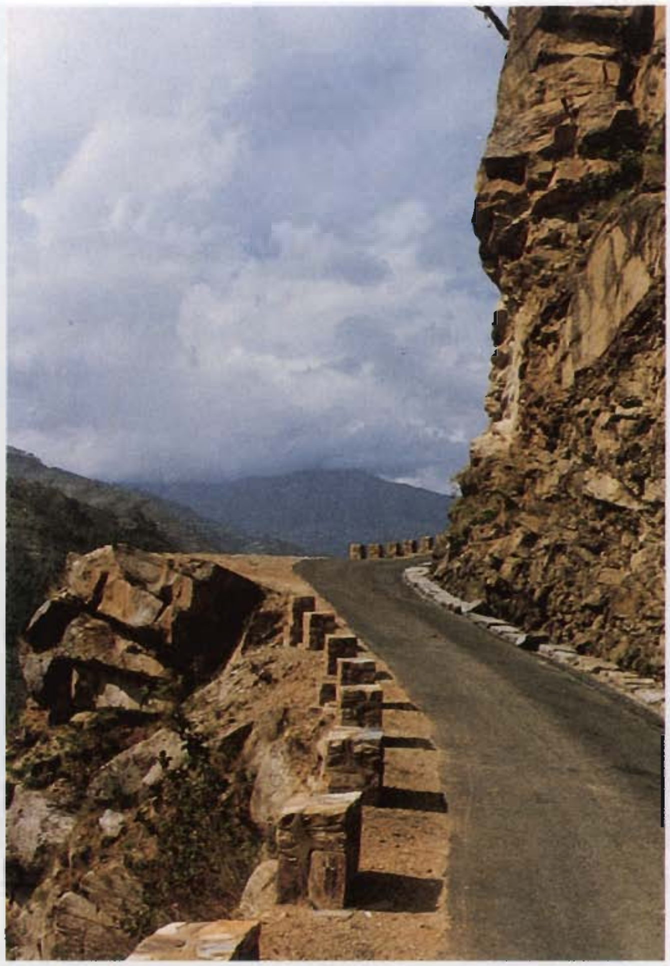


Plate 8: The whole road profile is cut into the sound rock.

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

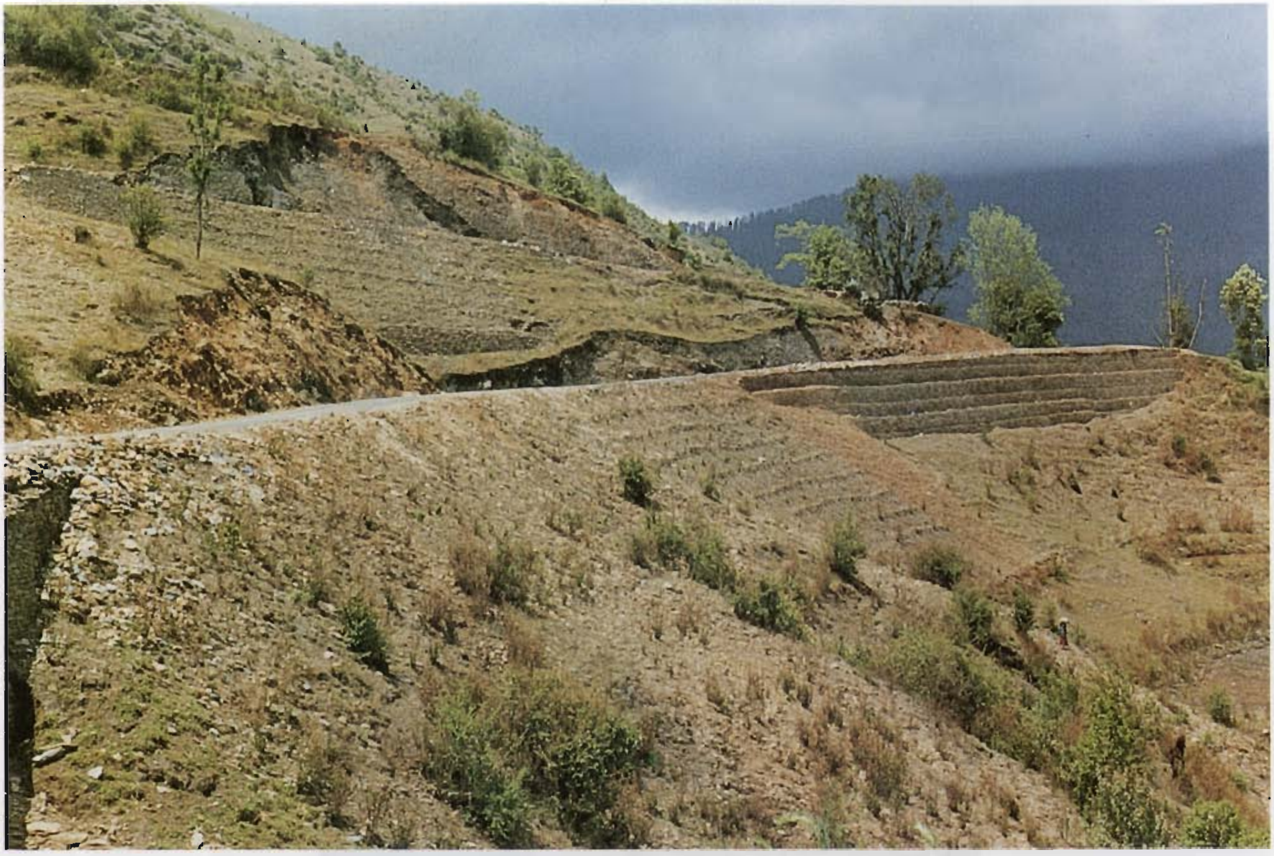


Plate 10: Cut and fill balance in the long section.

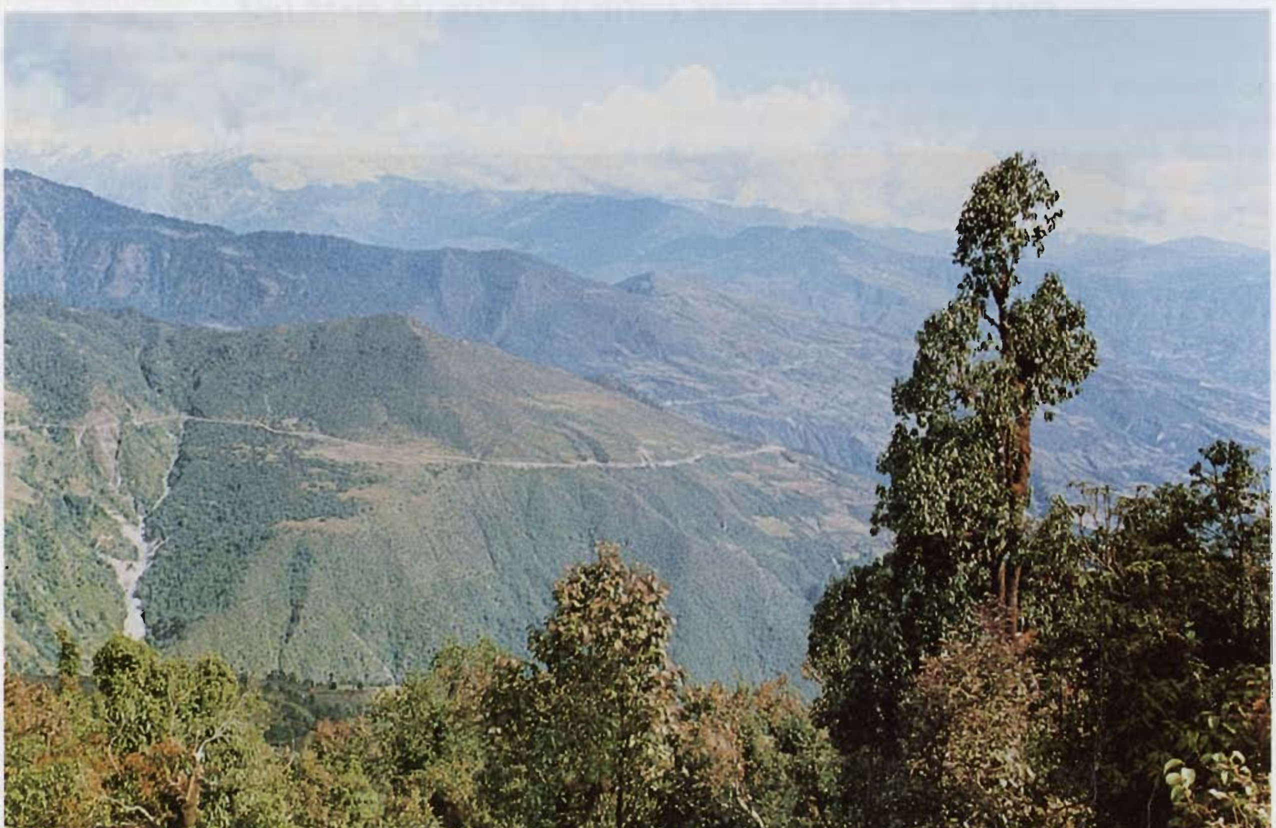


Plate 11: The road section between Kharidhunga Pass and Hanumante Pass.

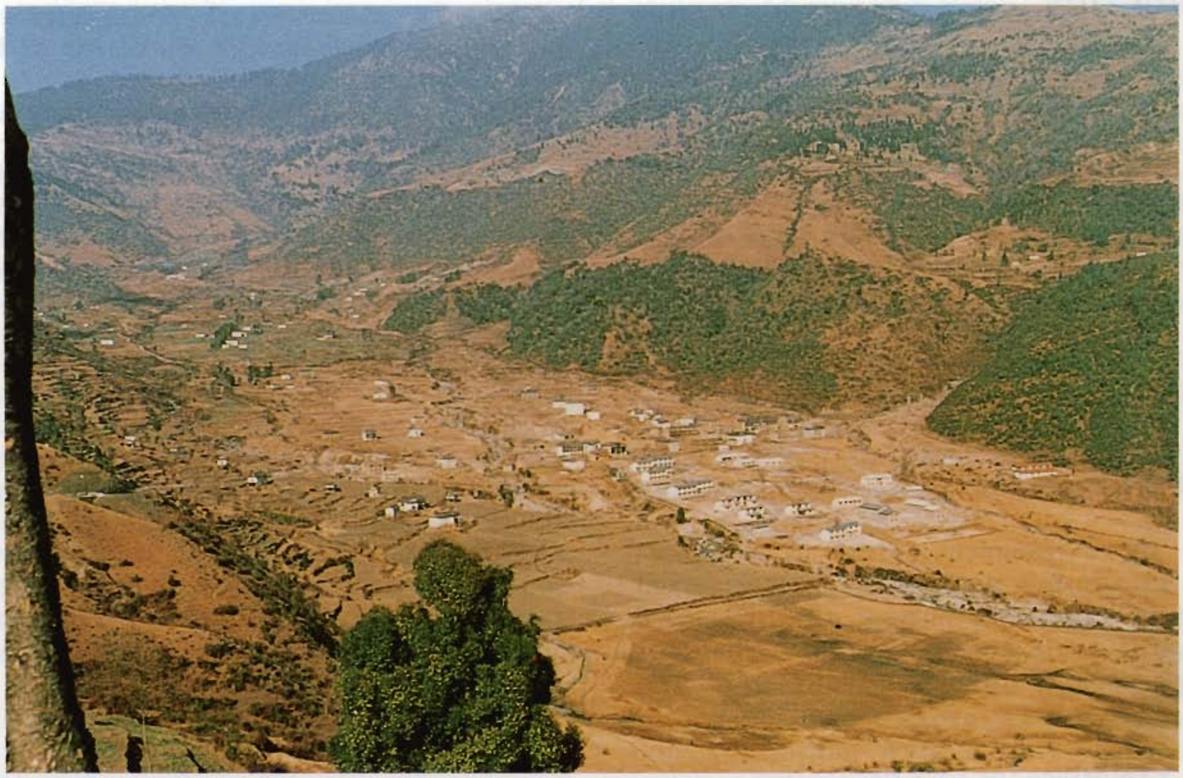


Plate 12: The Jiri valley is reached after a drive of 188 kms from Kathmandu (See Fig: 8).

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 Headquarter 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).

The LJR is designed as a low cost road and its construction is based on labour intensive techniques. These two facts were the deciding factors in the choice of construction methods.

TECHNICAL PROBLEMS AND THEIR SOLUTIONS

Material and Equipment

The above statement forced us as far as possible to use only locally available material and put in equipment only if the prescribed work quality could not be achieved by hand or the work became uneconomical. Therefore, only:

- o Explosives for rock excavation,
- o Galvanised, mild steel wire for gabions,
- o Cement for cement masonry and concrete works,
- o Concrete pipes for pipe culverts, and
- o Bitumen emulsion (60%) for blacktop works were procured abroad or in Kathmandu, if available.

Construction equipment was needed for

- o Rock excavation (rock drills and compressors),
- o Small size aggregate production (stone crusher),
- o Concreting works (concrete equipment),
- o Compaction (light vibro rollers and heavy rollers), and
- o Transport of more than 600 m distance (tractors, trucks).

This machinery (value approximately NC 5 million), as well as some project cars (value approximately NC 1 million), had to be very well maintained to guarantee smooth construction execution. A task which was not at all easily fulfilled as there were no reliable and adequately skilled DOR mechanics available. Even with privately engaged mechanics on the Swiss side, the efficiency was not according to demand and frequent breakdowns of machinery resulted in intolerable construction delays. This situation could only be brought back to normal after the appointment of a Swiss Mechanical Engineer who concentrated on appropriate training, proper spare parts management, and adequate maintenance of the plant (See Fig: 3).

Earthwork

As already mentioned, the alignment should be fixed in a way to achieve a mass balance over road section lengths where hand transport of excavated material is still economical (truck transport is not yet possible in the stage of earthwork). Only such an approach can guarantee a minimum of destruction of the environment along the road (Plates 13 and 14).

Surplus material should be deposited only in safe places where it is not in danger of falling down. Unsafe deposits can be supported by the construction of toewalls at the lower end. If the surface of surplus deposits is steep it should be protected with a vegetation cover to avoid surface erosion.

Surplus material of appropriate quality can be used for the construction of embankments if the geological and topographical conditions of the terrain allow it.

Where walls are necessary, various construction types are possible like concrete walls, cement masonry walls, dry masonry walls and gabion walls. For our specific situation, where material transports from outside had to be limited to the barest minimum (no road access yet to the different earthwork sections), only dry masonry and gabion walls were suitable. The dry masonry wall is about 3 times cheaper than the gabion wall, but can only be applied for heights of not more than 2m for the ms and not more than 5 m for the vs if load and geological conditions are uniform and the construction is properly executed (brick wall technique with binder and ledger). For higher walls and any geological and load condition, the gabion wall is the proper solution. It acts as a homogeneous and monolithic system and is very flexible against deformation without losing its strength. The galvanised zinc coating on the wire provides long term protection against corrosion and therefore, destruction. The filling of the gabion boxes should be done in such a way as to achieve a maximum filling (weight) using only stones of bigger sizes than the dimension of the meshes of the gabion boxes. Gabion walls should not exceed a height of 3 m for the ms and 8-10 m for the vs. A proper drainage of the foundation as well as the rear of the wall (filter bed) is of utmost importance for both types of walls.

Water Management Works

The extremely high concentration of precipitation makes it very difficult to achieve a controlled and slow water run-off. The basic principle is to collect not only the water from the slope above the road, but the whole road surface water too in the ms side drain and lead it to the nearest natural rivulet or brook. Therefore, the cross gradient of the road is normally kept to the ms, varying from 4% for straight sections and ms curves and 0% for curves turning the opposite way. In extreme cases, such curves can even have a cross fall of -2% depending on the long gradient and curve radius, but the water flow into the side drain must be guaranteed.

At the beginning we built only cement masonry side drains, except along sections of rocky underground. After some time this technique had to be reviewed because this side drain type is very expensive and our expectations concerning work quality were far from fulfilled (the construction contractor did not follow the execution specifications and we were not in a position to guarantee proper work

Plate 13: **This road has been completely hewn into the slope and the whole excavation material thrown over the vs road edge thus devastating all the vegetation below. Such huge scars can hardly be healed by erosion protection measures and will become bigger and bigger during the monsoon seasons and finally leave no other way than to re-align and reconstruct the road.**

Plate 14: The mass balance has been achieved. The road is hardly visible and its vicinity intact.

Plate 15: Embankment of more than 5 m height near Jiri. The surface is protected by the plantation of grass bunches.

supervision). Therefore, we changed the side drain concept and built cement masonry side drains only along sections with perennial water flow, perpetual wetness or silty sub-surface, to avoid uncontrolled penetration of surface water through the side drain into the underground, thus undermining the bearing capacity of the road substructure or producing a slide of the road section. On all other sections which had no rocky underground, dry masonry side drains were built which are about 10 times cheaper and the quality even better. Their disadvantages are the danger of water penetration (normally a certain natural soil sealing takes place during water flow) and more troublesome maintenance (clearing of drain). (See Fig: 9).

Standard Types of Side Drains

Our closely following the contour lines of the terrain had a positive impact on the size of structures, especially for crossing of valleys and gullies. In most cases, a simple culvert or causeway was the appropriate solution. In exceptional cases, slab culverts of a span of 4 m (6 nos), or small bridges of spans between 8 and 12 m (5 nos), had to be constructed. The only two big structures needed were for the crossing of the Sun Kosi and Tama Kosi River (72 m span each). In the case of water discharge, only culverts were built, whereas in cases with additional debris flow, causeways were chosen to avoid a blockage of the drainage system.

Where side drain water is discharged into a rivulet or brook the previous run-off volume is considerably increased and side as well as depth erosion of the gully is the consequence, if it is steep enough. Therefore, such gullies have to be protected by checkdams as far down as they are erosion endangered in order to break the water speed. In addition to that, the valley sides should be protected against slides by a plant cover. Very often, the gully bottom is of such poor soil quality that it has to be sealed and the water flow channeled to avoid the water breaking out against the gully sides, which results mostly in the destruction of the checkdams by scouring. Such channels were built with stone slabs and the joints sealed with cement mortar (Plate 19). The checkdams themselves were built with gabion boxes. They should not be higher than 4 m in order to avoid a too high water energy build-up. The crown of the checkdam as well as its steps have to be protected by stone slabs too where the water flows to avoid the destruction of the gabion wire and therefore, the tearing off of the checkdam by the water and debris flow. Usually, such valleys have not only to be protected in their outlet but also in their inlet to the road crossing point.

Gabion structures were also used to channelise rivers above the road bridge and for the construction of bridge abutments. In such cases, it is very important to protect the gabion structure (e.g. the gabion wire) from fast flowing water which always contains sand or even small stones and destroys the structure very fast. This can be achieved by putting big size boulders in front of the structure so that the water speed along it is reduced to almost zero.

To obtain maximum slope stability it must be drained in such a way as to guarantee that most of the rain water can flow off superficially. This has to be observed especially for ms slopes which have been made steep by cutting. It can be done by diverting the water coming from above the cut slope through catch drains running parallel to the upper end of the slope towards the nearest gully and in case of seepage in the slope itself, by the additional construction of vertically running French drain systems of "I" or "Y" shape which will lead the water directly and fast into the road side drain. A combination of French drain systems with bioengineering measures (planting of trees with good water absorption capacity like alders) will increase the slope stability even more.

Road Base

To best serve its purpose as the backbone of the region's concentrated integrated development efforts, the LJR is designed as an all-weather road. Due to the prevailing climatic conditions and the average gradient of the road, surface protection was absolutely necessary. Our experiences along the first 30 kms soon showed that the foreseen gravel road with 2 layers of water-bound macadam was not a satisfactory solution because the coherence of the road surface was too soon lost due to the extreme weather conditions. During the long dry period the silty surface soil which acts as a binder is blown away as dust. The layerwork is loosened by the traffic and during the rainy season it is swept away by the force of the water. Therefore, a large part of the layerwork has to be rebuilt every year. A solution which in the long run costs more than an additional blacktop layer at the beginning. Taking this into account as well as the scarcity of available stone material of proper quality along the road,

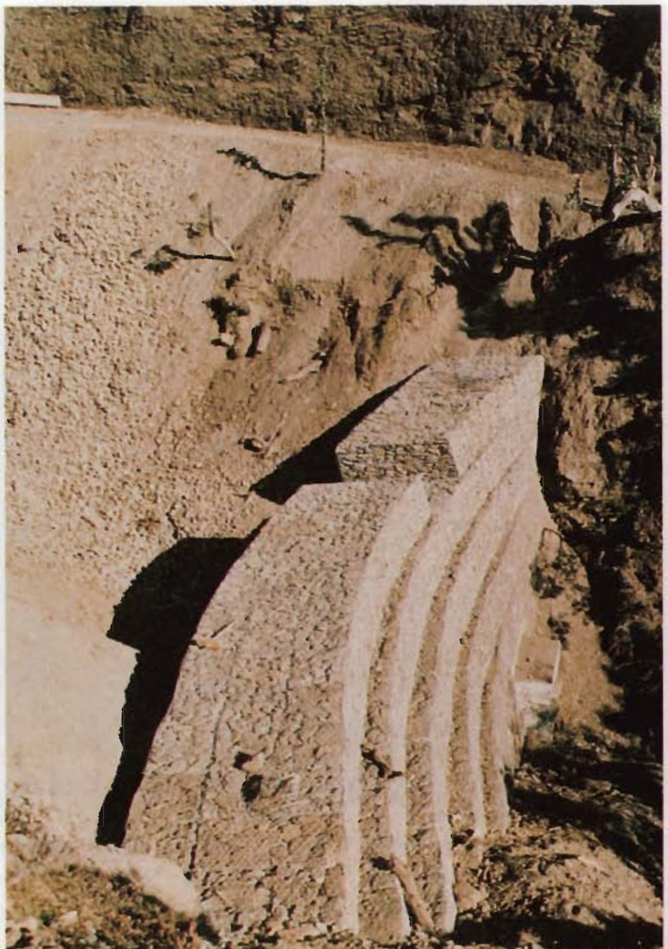


Plate 16: Vs gabion retaining wall under construction. The last layer is 3 m wide.

the initial concept was changed and a blacktop layer was added.

After the preparation of the sub-grade surface (excavation of 10 cm sub-grade material) which should be level enough to allow a proper water run-off into the side drain, the first layer of the road base, the stone soling, is laid by placing the stones vertically and as tightly as possible together (Plate 5). This layer has a thickness of 15-20 cm and should consist of stones of fair quality. The holes on the soling surface should be closed with dressed stones and some cohesive soil to achieve a smooth surface. Roller compaction finalises the work.

The two gravel layers (12-14 cm and 10-12 cm thick) consist of good quality aggregates of a size of 0-70 mm, well graded, for the first layer and of a size of 0-55 mm, well graded, for the second layer. The layers should be brought in so that the added binding soil material is homogeneously distributed throughout the layer to guarantee equal conditions for force transfer of traffic load. Water has to be added before the layer can be compacted. The result is the so called "Water-Bound Macadam" layer.

To achieve a good quality hand made blacktop layer, several different versions have been tried out. Finally, the most successful version consisted of a layer of 4 cm full grouting with aggregates of 20-40 mm, covered by key aggregates of 5-10 mm, plus a layer of 2 cm pre-mix carpet with aggregates of 5-20 mm covered with sand. Most important are aggregates of a very hard but not brittle quality. This version proved to be the only feasible one

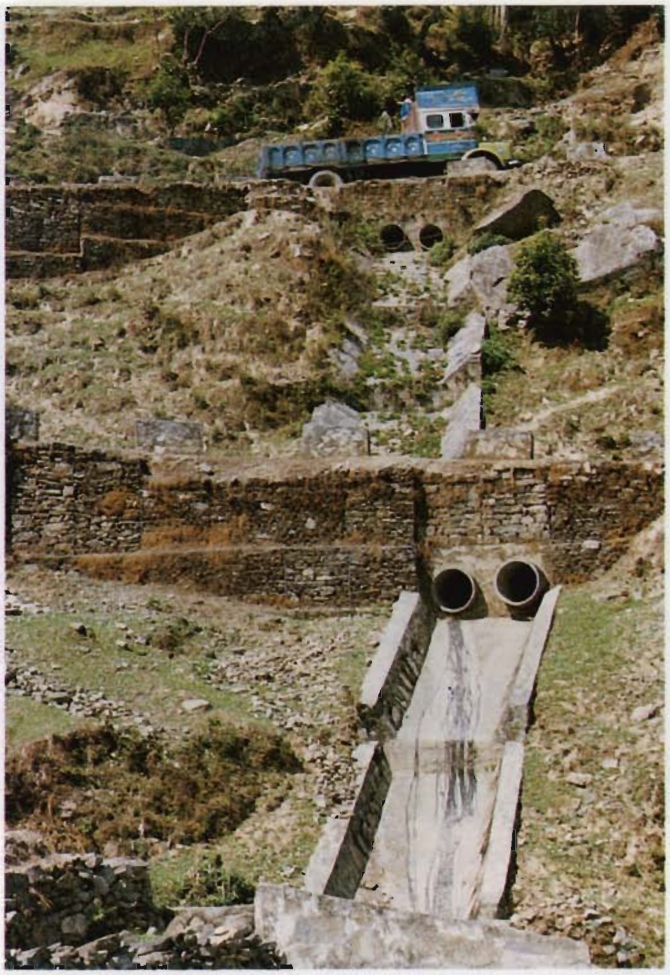


Plate 17: Two subsequent double pipe culverts 0.60 cm with controlled outlet over some distance.

of proper quality under the prevailing circumstances (material, binder, contractor, technique).

ENVIRONMENTAL PROTECTION

General Remarks

The best method to prevent erosion would be not to touch the mostly unstable slopes of the hills of Nepal at all. They should be left uninhabited with their original plant cover (forests). Obviously, this is not possible as this belt of land is the habitat of some million people who have to manage their living on it. Therefore, the unstable slopes have to be used by different activities in favour of this population. One of these activities is communication which nowadays can only function if roads are available.

Slope Drainage System

But the construction of roads is a massive interference with the environment and should therefore be undertaken with the utmost care. In other words, if one has to tread without leaving load imprints, it is better to tread lightly. Thus, a "kid-glove" approach to road construction activities should be applied which includes automatically the principle of prevention and minimises erosion as well as construction and maintenance cost (see Fig: 10). Following this line, slope failures have to be immediately repaired to prevent further extension

Plate 18: Causeway with water guiding inlet and outlet structures.

Plate 19: Inlet protection of a gully by two checkdams with channeled water flow and stone slab covered checkdam crowns and steps.

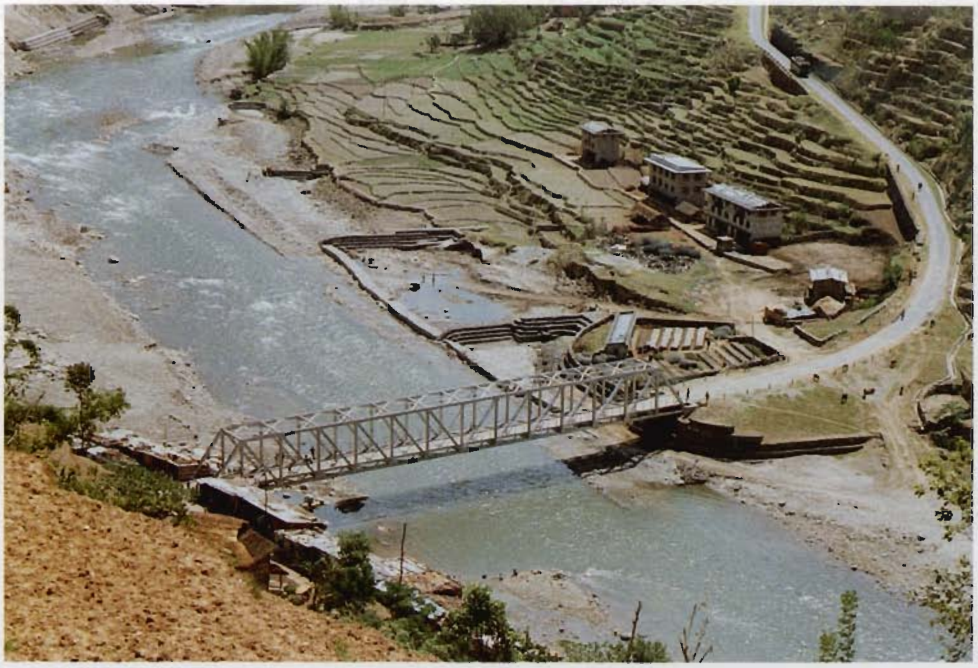


Plate 20: Sun Kosi Bridge. The erosion protection structure above the bridge consists of 4 spurs on the right embankment and 5 spurs on the left side, of which only the 2 highest ones are still visible (the other ones are already covered by river gravel and have therefore fulfilled their task)

and avoid the possibility that they become uncontrollable. Where the water run-off is not tightly checked, the system has to be improved to prevent 'creeps' and slides.

The causes of slope erosion can be attributed to various reasons. A concentrated deluge of surface water run-off can create erosion. Steep slopes (natural or cut) tend to fail. Water-saturated zones, where the sub-surface water exerts uplift, are erosion prone areas and consequently creep or, when the water acts as a lubricant, slide. A thick blanket of loose soil, boulders, or debris over rock strata falling with the slope invite erosion. Even without such a blanket, the rock slope is quite unstable and can fail.

Slope Stabilisation

To improve the stability of a slope, or to regain it after a failure, three different measures can be applied:

- o To improve the slope by getting it as dry as possible (drainage system), or
- o To support the slope by structures, or
- o To stabilise it by bioengineering methods.

In most cases these three methods should be combined to achieve the optimum. Before any work can start, the reason for the failure has to be found in order to choose the proper repair measure. Therefore, the first work step should always be the proper drainage of the slope.

Erosion protection structures include those which have to retain soil masses like toewalls and retaining walls and structures which should prevent slope surface erosion, like stone layers, systems of stone arches, and terraces.

Bioengineering erosion protection measures are mostly directed against slope surface erosion and consist mainly of sowing plants suitable to the climatic conditions of the site. Most important is the plant's capacity for deep rooting, thus tightening together the soil surface, and water absorption power (drainage effect). Another surface erosion protection measure is the combination of planting and mini terrace construction out of wood. Finally, mini toewalls made out of wood were also constructed. The three following Plates 21-23 show applied bioengineering measures in the LJRP.

It has to be emphasised that areas with new plant cover have to be fenced off or watched by watchmen to avoid foraging by free grazing animals, causing an eventual failure of the protection measure.

Erosion prevention measures have to be applied from the beginning of road construction and continuously throughout the whole life span of the road. This implies the existence of nurseries along the road to provide the needed raw-material for such measures (Plate 2).

In case structures or bioengineering methods can be applied with the same chances of success, the latter should be chosen as they are much cheaper.

Execution of Blacktop with Bitumen Emulsion

Blacktop surfaces consist of two main components: mineral aggregates and binder. The task of the binder is to hold and cement the aggregates in a coherent structure strong enough to sustain the most rigorous traffic.

Till now, the prevalent practice in Nepal was the use of bitumen as binder. Bitumen is a by-product of crude petroleum distillation and is solid at ambient temperature. For road construction it must be applied in a fluid state at a temperature of 160° C. This heating up is normally done at site by the use of firewood. For the blacktopping of our road the demand for firewood would have been approximately 2,200 mt or, in other words, the felling of about 1,000 ha of forest area would have been necessary. This statement is valid if no forest management system exists. Otherwise, it would be the yield of said area. Such a measure would be completely against the objective of both the projects (LJRP and IHDP), which is improving the ecological balance of the area.

Therefore, another solution had to be found which allowed a cold application of the binder. This is possible with bitumen emulsion. Bitumen emulsion is a heterogeneous liquid mixture of finely dispersed bitumen globules in water at ambient temperature. From the technical point of view, both binder types give the same blacktop quality if the work specifications are carefully applied. (The presently used method of heating up bitumen in hillroad construction is not satisfactory, giving only 100-120° C whereas 160° C would be needed. In addition to that, the used aggregates are cold,

Plate 21: A vs slope surface protection by bioengineering: fast growing branches fixed on the slope by gabion wire and nailed with cutting sticks.

Plate 22: Same bioengineering technique, but covering the branches with wire netting instead of nailing them. This cover has to be dismantled after due time. The protected area is fenced off with barbed wire.

Plate 23: A vs road slope is protected by mini toewalls out of wood to retain the dumped surplus material and by planting grass bunches with fast growing and deep rooting properties).

Plate 24 Vs slope protection after slide with 2 checkdams (only the upper one is visible) and mini terraces with plantation just after completion of work).

thus reducing the success of this technique further). Both methods allow a labour intensive technique. The main difference is shown in the price of these binders. A cost comparison on the basis of the firewood market price alone shows a difference of about NC 20,000. - /km blacktop in favour of bitumen. But this calculation does not consider the production cost of firewood (reforestation). Including these costs, the use of bitumen emulsion is equally as expensive as the use of bitumen. This fact changes in favour of bitumen emulsion (NC 6,000. - /km) if it is produced in Nepal and the transport of the 40% water content in the emulsion from Calcutta is no longer needed. (Today, such a bitumen emulsifying plant already exists at Hetauda).

Therefore, the application of bitumen emulsion for blacktop surfacing and maintenance in the hills of Nepal is by far the best method in terms of economy and environmental protection if labour intensive construction methods are applied.

WORK EXECUTION

The Contractor

Nepal's construction contractor system has developed only during the last one or two decades. Therefore, only a handful of contractors have gained enough skill and experience to competently execute construction contracts of a certain standard. HMG/N has established a contractor classification system with regard to the contractor's financial power, professional staff, construction equipment, and experience. This system is based on a contract cost ceiling for each class as follows:

Class A above NC 10 million

Class B below NC 10 million

Class C below NC 3 million

Class D below NC 1 million

Even for A class construction companies, the existing infrastructure is very modest in regard of their professional staff (mostly employed only for a specific construction contract) and their construction equipment (a few trucks and eventually a roller and (or) a stone crusher). Their executing site engineer is very often not at site, leaving the responsibilities to an overseer. It is evident that these contractors have to base their work on labour intensive techniques, engaging sub-contractors for the work execution along their section. For the construction of our road, we engaged A and B class contractors for technically more difficult work like water management, layerwork, and blacktop, whereas simple tasks like earthwork were awarded to lower class contractors. For the last 40 kms of earthwork we engaged piece contractors (identical with the sub-contractors above) in order to obtain a wider sharing of financial profits, to improve training opportunities, to build up local knowledge and infrastructure, and to gain more direct influence and control over the work.

Plate 25: Again, a slide protection with structures consisting of a footwall with stone layer above and systems of stone arches (not visible) combined with planting of vegetation (3 years after construction).

Plate 26 : The upper half of the Plate shows a piece contract earthwork section of a length of 20m.

These piece contractors were not classified in the HMG/N system and got only contracts worth less than NC 50,000.- . This financial frame limited the construction sections to only 20-200 m length depending on nature of terrain and work volume (Plate 26).

The disadvantage of the piece work system for the project lies mainly in the considerably increased and complicated site supervision, as well as in the much bigger administrative work.

The motivation of the contractors towards their work is not much influenced by principles like work quality and timely work execution but mostly by making profit. We had, therefore, many hard fights with them to get a more or less acceptable construction quality and to prevent huge delays in the work execution with its negative effect of inflation and therefore, increase of construction cost. The only power we had against them was the keeping back of payments, or refusing to take measurements for bad quality work.

Another main obstacle to timely work execution was the difficult awarding procedure for contracts due to local influences; especially the awarding of piece contracts was more than delicate. According to the project requirements we wanted contractors who did their job in time and of good quality, whereas the local leaders wanted their villagers to be preferred. Unfortunately, these were often not identical and compromises took their time which always resulted in a reduction of the available length of construction season. The fact that according to HMG/N rules, the lowest bidder always had

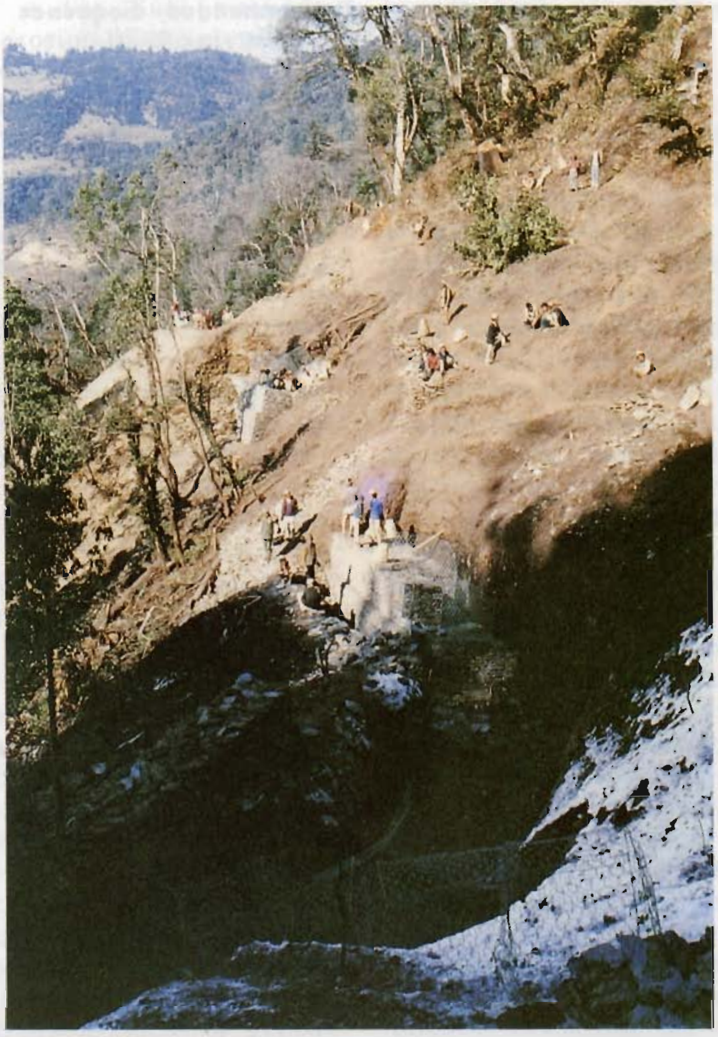


Plate 27: Erection of vs walls before the excavation of the road profile starts.

to get the contract, notwithstanding how low his bid was (35% under the cost estimate in exceptional cases), did add to the problems as they often were not in a position to execute certain work.

Earthwork

As already mentioned, a "kid-glove" approach towards road construction activities is imperative to deal successfully with unstable slopes. Therefore, the sequence of earthwork activities is of great importance and should be undertaken as follows within the cross section:

- Removal of trees and other vegetation only within the border line of construction to secure the stability of the adjoining slope to its maximum (eventually, re-use of wood for bioengineering protection measures),
- Eventual last horizontal shifting of alignment for economisation of cost,
- Removal of topsoil within the same stripe and deposition above the cleared area for re-use,
- Excavation of vs retaining wall foundations, if any, (surplus material has to be deposited safely to avoid erosion, stones should be collected and stacked above the site for the filling of the gabions); the foundation has to be drained properly to guarantee dry and

stable conditions for the retaining wall,

- Erection of the retaining wall and tight backfill with stones (Plate 27).
- Cut off the necessary road profile and fill the vs gap behind the retaining wall with appropriate soil material in horizontal layers of not more than 30 cm thickness (loose) which have to be compacted (hand tampers of approximately 20 kg) after water has been spread over the layer; stones have to be collected and stacked for re-use,
- Drainage of ms slope,
- Excavation of ms toewall foundation, if any,
- Erection of toewall and backfill,
- Construction of temporary side drain (5% crossfall of road surface towards the ms),
- Distribution of topsoil on road slopes as well as planting and sowing of road slopes shortly before the beginning of monsoon.

Recommended Sequence of Earthwork Steps Within Cross Section

It has to be emphasised that with the completion of earthwork and before the monsoon period starts, a temporary water-management system must be constructed to avoid erosion due to changed waterflow along the road area consisting of at least:

- A dry masonry side drain,
- Gully crossings must have a temporary causeway, including a stone soling where the water flows and a minimum of inlet and outlet protection structures,
- Ms slopes must be well drained including necessary catch drains above the cut slope.

Furthermore, the above mentioned bioengineering slope protection measures have to be done around May-July to prevent slope wash-outs and slides (where necessary, these works have to be protected from animals by fences or watchmen).

At this point, a word against the usual practice of stone collection for construction

Plate 28: Workmanlike tree plantation results in surprisingly big growth areas. Alder trees below and above the road three years after plantation.

work out of river beds is due. Such methods result in side and depth erosion of the river bed and very often in slides of the adjoining area due to increased velocity of the waterflow and should be strictly prohibited.

The big problem of material transport within earthwork sections, where there is not yet any access for trucks and tractors, leaving only hand transport open, could be considerably improved by the use of wheelbarrows of proper make. Our experience in the maintenance phase of the project with wheelbarrows having pneumatic wheels with their centre of gravity deep enough and closest to the wheel axle were very encouraging as the labourers immediately accepted this new mode of transport and increased their transport capacity manifold.

Watermanagement Works

The execution of watermanagement works is mostly connected with cement masonry and concrete works (side drains, culverts, causeways, and in and outlet structures). Our experience with such type of construction works is rather mixed; nothing against it in general, but if not executed according to the specifications, one should consider choosing another construction technique to avoid high losses of money for the procurement of expensive cement.

Due to negligence and other dubious reasons, the contractor did not follow the work prescription, using dirty and completely dried out stones, sand of too fine grain containing enough mica and not enough cement. Furthermore, the after-treatment of completed cement works was not done properly or even forgotten. The result was very poor work quality comparable in solidity with normal dry masonry work. Therefore, cement masonry and concrete structures should only be built if the work supervision is strict enough and quality tests are carried out.

Layer and Blacktop Works

The construction of roads creates an enormous demand for fair to good quality stones as construction material. Therefore, every excavated stone of appropriate quality should be deposited for re-use (walls, watermanagement structures, road base and blacktop). Approximately 2 m^3/m^1 road was needed for layers and blacktop and even more was required for the rest. A rough estimate for the construction of the LJR amounts to more than 500,000 m^3. Such quantities cannot be collected on the basis of the normal road profile excavation. Depending on the terrain conditions, it may be possible that the major part of stone material for the earthwork (wall construction) can be gained out of the road profile excavation. But for the rest, quarries have to be opened as close as possible along the alignment (economisation of transport cost). The working of the rock has to be well planned and managed to get the maximum volume of stones with a minimum of environmental damage and explosive consumption (blasting techniques are still of very low standard and therefore uneconomical in Nepal).

In our project, we ordered that the crushing of stones for layer work to sizes bigger than 20 mm be executed by hand. For smaller sizes, the stone crusher was used as such sizes cannot be produced efficiently and economically by hand. The fractions 3-5 mm for the premix layer of the blacktop could not be any more economically produced by our crusher and had to be bought partly from a quarry in the Kathmandu Valley.

A special remark has to be added regarding the execution of the blacktop layers. It was not possible to execute the blacktop surface we considered the best solution from the technical point of view as we had not the means to force the contractor to strictly follow our specifications:

- o The clips were not of the right size, were not graded well and contained too much dust. In addition to that, they were often wet;
- o The preparation of the surface of the second layer was not done properly, leaving it too smooth, so that an eventual premix layer was in danger of gliding on it under heavy traffic at steep sections;
- o The prescribed thickness of the blacktop layers was often not observed;
- o A half grouting was not possible as the contractor was not able to add the correct amount of bitumen emulsion. To cope with our limited means of work supervision and to achieve, nevertheless, an acceptable blacktop quality we

finally chose the solution explained earlier which gave quite satisfactory results.

Bioengineering Works

Although bioengineering is a rather cheap and efficient technique to prevent erosion, it should be carried out carefully and workmanlike to achieve best possible growth rates of planted or sown vegetation. Especially in the first few weeks or months when the plants are in a critical stage of survival, fast rooting and growing is essential to achieve the expected erosion protection effect. At the same time, the plants are often exposed to free grazing animals which like young vegetation the most.

We tried to protect bioengineering-treated slopes by two measures:

- o The selection of plants was guided by the criteria of choosing non-palatable plants e.g. Banmara (Eupatorium adenophorum), Utis (Alnus Nepalensis),
- o Employment of watchmen or fencing-off of area.

WORK SUPERVISION AND QUALITY CONTROL

It is not enough to issue clear work specifications to the contractor as he tends to do the work in the easiest possible way which does not necessarily correspond to the specifications. In general, his main motivation is not to achieve good work quality but to get the highest possible profit out of the contract.

From the economical point of view, the most important factor is quality. A structure of bad quality may last easily only half the time good quality work lasts. In other words, you can build and maintain a road network of good quality measuring 2,000 kms with the same amount of money as a bad quality road network of only 1,000 kms.

This fact should force the project to accept only the best possible quality for its investment and maintain, therefore, very tight work supervision, including comprehensive quality control. The contractor should be paid only for work which has been done according to the specifications and which has passed quality control successfully. Repair and improvement works have to be carried out before the respective installment is paid.

Another main factor to keep the investment on the estimated level is timely work execution. Delays in the construction programme can have enormous consequences on the financial side because of inflation and running fixed cost. Calculations in our project showed financial losses of approximately NC 1.3 million/month during the construction season 1981/82.

Such delays must not only be charged to the sometimes very slow acting HMG/N administration, but also to improper guidance or supervision of the contractor's planning and programming of work. Here, too, strict and prospective supervision of the contractor's activities can save considerable investment cost.

In the LJRP we had difficulty establishing efficient site supervision having only 5 Swiss site engineers when construction was at its peak during 1981-1982 along the full 110 kms. This fact was very significant when the feasibility of different technical solutions was checked. It was a deciding factor e.g. for the making of side drains and blacktop.

The following construction material and works were tested periodically:

Material:	Work:
. soil	. Cement masonry
. sand	. concrete
. rock	. blacktop
. gabion wire	
. cement	
. bitumen emulsion	

Most of the test samples were sent to Swiss laboratories as the reliability of Nepalese labs is not very constant nor are they yet equipped for certain tests.

MAINTENANCE

With the completion of the preceding chapter, the most essential aspects of the construction of rural roads in the hills of Nepal in general and the LJR in particular have been elaborated.

But with the completion of the construction a road is not necessarily serviceable during its life span. This can only be guaranteed by proper maintenance and the better this maintenance is executed, the longer the road will remain serviceable. Moreover, maintenance has to be started not only when first damages have appeared, but right after the construction has been completed.

GENERAL SITUATION IN NEPAL

The importance of maintenance for the securing of investments has only in the last few years gained acceptance among HMG/N officials. This fact as well as insufficient financial resources have contributed to the often deplorable state of roads in Nepal just a few years after construction completion. It is evident that badly maintained roads have not only a shorter life span but also a negative effect on the wear of the vehicles plying on them and are, therefore, twofold uneconomical.

LJR MAINTENANCE PROJECT

Objectives

With the completion of the road construction (May 1985) the project started its third phase: the Road Maintenance Phase. This phase is again implemented under the Nepal-Swiss Cooperation and lasts 8 years (1985-1992). Its objectives are:

- Build-up of an efficient maintenance system to secure the construction investment as well as to function as a pilot project for the maintenance of hill roads in Nepal;
- The economisation of maintenance by giving strong emphasis to preventive maintenance methods;
- Execution of the work based on labour intensive techniques to generate employment and income for the local population of the project area;
- Maintenance activities not only limited to the road structure but also including its adjoining areas as far as they could affect the security of the road;
- The maintenance of the blacktop layer using bitumen emulsion as binder to support ongoing efforts towards the regaining of the balance of the environment;
- Appropriate training of Nepali technicians, supervisors, and labourers to guarantee smooth know-how transfer in favour of the locally existing infrastructure;
- Establishing a monitoring system to determine the technical, financial, and socio-economic impact of the road.

Organisational Set-Up

Unlike the organisation for the maintenance of Nepal's road network which is centralised in Kathmandu, the LJR maintenance is decentralised and forms a separate unit with its base and administration at Charikot. However, for the first 3 years project management responsible for the implementation of the project is stationed at Kathmandu. After that period, Charikot will take over under a Nepali Road Inspector and his Swiss counterpart.

Besides the maintenance division (headquarter) at Charikot, 4 maintenance subdivisions are responsible for the work execution, namely Thulopakhar (km 18), Charikot (km 54), Maina Pokhari (km 87), and Jiri Market (km 107).

Maintenance Cost (price basis 1984)

Not considering some additional cost for the reinforcement of the blacktop layer on some sections and inflation cost over the 8 year maintenance period, we have estimated approximately NC 5.2 million/year for the road maintenance which amounts to 2.1% / year of the construction cost (bitumen emulsion procurement in Nepal).

After one year of maintenance experience this estimate seems quite appropriate.

FIRST EXPERIENCE

One year after the project's inception the difficulty of carrying out the objective of preventive maintenance became apparent. We feel that our means (finances as well as personnel) were too limited for preventive maintenance in the proper sense of the word and therefore, we were only able to concentrate on top priority work along the road and had to limit the concerned adjoining road areas to the barest minimum.

Another aspect which became obvious during the construction is the role the local population should play vis-a-vis the road. As end beneficiaries they should identify themselves with the road as a new element in their environment and experience it as a means for communication, development, and a significant rise of living standard. The objective of this identification is to foster an essential awareness of individual as well as group responsibility towards the road and its environment in terms of maintenance and as a part of the ecosystem.

In other words, the local population should be continuously educated about some fragile features of road systems, as for instance:

- The importance of the proper functioning of the water management system (no throwing of waste into side drains or unauthorised diverting of water from the system to serve a person's immediate purposes),
- Areas fenced-off due to bioengineering treatment should be respected and kept free from foraging animals and fodder or firewood collecting people,
- The remaining forest should be well managed for the benefit of the local population and the safety of the road.

SUMMARY

It is undisputed that the existence of roads is an imperative requirement for smooth development of rural areas. Unfortunately, roads have very often a rather destructive impact on the environment of adjoining areas and therefore, a bad reputation among experts conscious of the natural environment. Road builders should and can do a lot to improve this unpleasant situation by giving top priority to environment protective measures. Such measures should be an integral part of all activities from survey to design, construction and through the whole life span of the road. A precondition to success in this regard is the active cooperation of all concerned people (politicians, government officials, engineers, labourers, and farmers) who should be or become aware of the problems.

What were the main difficulties we had to overcome in the LJRP, not only in terms of environmental protection, but also in general?

o The cooperation between Nepal and Switzerland is based on the so called "Counterpart System" which is without doubt a good system with many advantages (e.g. possibility of know-how transfer, identification of DOR with project) but it also requires from both the individual counterparts a lot of goodwill, the readiness to listen and to understand the socio-cultural situation of the other, mutual confidence and respect, taking one's share of responsibility, etc. This is quite a difficult task if the not always uniform interests of the individual partners is considered. If the partners do not succeed in their cooperation the project as a whole might suffer.

o Another problem was the compulsion to apply the HMG/N administration's rules and regulations for project implementation. Here too, such a project concept has enormous advantages (HMG/N's identification with the project, strengthening of HMG/N's administrative bodies, etc.) but serious disadvantages, too, like being dependent on an administration which is rather slow and inflexible, creating huge delays in the construction programme and therefore, considerable cost increases (inflation, running fixed cost). This problem could be lessened considerably by the introduction of some special regulations for the 2nd project phase. It is clear, that such alterations can only be considered as curative measures. Real improvement of the administrative system must aim at its roots (e.g. delegation of authority).

o Without the timely payment of land compensation to the concerned farmers along the road, the local population will not cooperate with the project. A precondition for the identification of the local people with the project and the basis for successful implementation in the long run is the cooperation of the local population. Again, the 2nd project phase gave the opportunity to solve the problem (funding of land compensation by the SG).

o The awarding of piece-contracts to local petty contractors is a lengthy and arduous procedure which can cause serious delays in the construction programme. The issues here are understandably complex and, as in all countries, many factors other than simply work efficiency affect the choice of contractors and labour. Naturally the project prefers contractors who guarantee good work quality and timely execution, and would wish to make this the only criterion. The situation could be improved by introducing a procedure which allows a preselection of 150% of the needed number of contractors, purely on grounds of ex-

perience and efficiency with the final selection then taking into account the judgement of local leaders

- o A technical problem of comprehensive implications is the achieving of a smooth and controlled surface water run-off. The solving of this problem is the key not only to minimize maintenance cost but also the overall investment in the long run. Besides that, it is a substantial contribution to efforts aiming at avoiding environmental damage. The most important measures in short are:

  - o Proper drainage of water-saturated slopes and spring run-off,
  - o Sealing of side drains against water penetration into the underground along slide endangered sections,
  - o Side drains should be discharged only into natural brooks, rivulets, and rivers,
  - o Steep gullies carrying an increased water volume due to road water discharge should be protected by check-dams as far down as necessary to avoid depth and side erosion of the riverbed.

- o Another far reaching issue is the quality of construction material and work execution especially in regard to long term cost savings. Only rigid site supervision combined with hard punishment for the contractor in case of bad quality can be the right solution. The execution of quality tests is a complementary method to force the contractor to do a good job. Our big problem was the lack of sufficient Swiss supervisory staff to guarantee consistently good work quality. Therefore, we had to adapt certain construction techniques to tackle the problem (side drains, blacktop).

- o The problem of the selection of an appropriate binder for the blacktop layer could be solved quite easily after tests had given encouraging results in favour of bitumen emulsion. We could, therefore, avoid using a binder (bitumen) which has to be heated up with firewood for its application. A cost comparison of the two techniques shows a difference in favour of bitumen application if only the market price of firewood is considered. This difference becomes invalid if the cost of regrowth of firewood (reforestation) and the existence of the new bitumen emulsifying plant at Hetauda is taken into account. It is, therefore, strongly recommended to use bitumen emulsion as binder for hillroad construction and maintenance if labour intensive methods are applied, to save valuable energy resources in favour of the local population who is completely dependent on it.

- o The World Food Programme support for the project had mixed results. On the one hand it helped to stabilise the local market situation, but on the other hand, the problems created by the mostly unreliable distribution of food were quite serious at certain times when no food was available over long periods. The labourers ran away from the site and the work came to a standstill. We were not able to improve this unhealthy state as we had no say in the matter. For future, similar arrangements HMG/N should leave the responsibility for the transportation and distribution of food to the project itself to guarantee proper coordination between WFP and the construction programme.

Fortunately, our project agreement allowed us to take advantage of lessons we were taught during the project implementation by nature or the prevailing circumstances. Several times we had to reconsider whether and how our proceedings should be improved. The following represents the most important changes in our course of action:

- o Initially, we designed the road to be cut completely into the slope in order to have it secure enough if slides should happen later on. This philosophy proved to be completely wrong as our experience showed during the monsoon. A maximum of surplus material from the road profile excavation had to be deposited as closely as possible (no access for mechanised transport yet), but safe places were mostly not available leaving only the possibility of throwing it down over the road edge. These loose soil masses started to slide down as soon as the monsoon began. But the upper road slopes which were much steepened in the course of road profile excavation failed too. The disaster along the first 6 kms was complete as this section is characterised by a winding upwards of the road with several hairpin bends in a narrow corridor (Cover Plate). Thereafter, we designed the road in order to reach a mass balance in the cross section if possible and over short sections in the long section to minimise surplus material. It is evident that this proceeding results in higher earthwork cost as vs retaining walls become necessary.

- o In the course of this philosophy, the sequence of earthwork activities had to be changed to respond to environmental protection aspects. The following is the ideal sequence:

- o Collection of topsoil for re-use (bioengineering measures) above the road profile,

- o Construction of vs retaining walls, if any,

- o Excavation of road profile and backfilling of vs walls,

- o Drainage of ms roadslope, if necessary,

- o Construction of ms toewalls, if any,

- o Construction of temporary side drains,

- o Bioengineering treatment of road slopes.

Rock material gained from the excavation has to be collected for re-use (construction of walls, side drains, stone soling, etc).

- o It happens again and again that traffic forecasts are inadequate. This was also the case for the LJR where traffic censuses reach already 200% of the estimated number of trucks in the first year after the completion of construction. This fact forced us to execute a blacktop reinforcement programme on the first 60 kms. But not only was the number of trucks underestimated, but the amount of overloading too, especially where the mine transport from Kharidhunga to Lamosangu was concerned. Our calculation was based on an overloading rate of 50%. In reality, we had trucks with 75% overload!

- o Comparisons between gravel and blacktopped roads show that the long term investment (construction and maintenance cost) is lower for blacktopped roads if their gradients exceed a certain limit. In the case of the LJR this result is enhanced by the fact that the occurrence of suitable gravel material along the road is too limited to maintain a gravel road during its assumed life span. It was, therefore, decided to revise the initial concept and build a blacktop road surface.

- o In the sequence of road construction activities the critical stage is reached when the earthwork is completed. Normally, earthwork construction lasts a full construction season and the watermanagement works can only start at the beginning of the following season. Therefore, the monsoon hits a structure which is not yet armed accordingly and serious damage will be the consequence if preventive measures are not taken in advance. Again, we have been taught accordingly on the first 6 kms. These preventive measures consist of two things:

- o Construction of a temporary water management system consisting of dry masonry side drains and river crossings (causeways),

- o Bioengineering measures on the adjoining road slopes.

These measures have to be executed before the monsoon starts.

- o Finally, a side effect of our road base construction was the finding that the stone soling layer could be a solution for an improved gravel road surface of much better durability than the water bound gravel surface has. It is therefore recommended to have as the first layer a normal gravel layer, followed by a thin sand layer (5 cm), before the stone soling is added as the surface layer.

Given the present situation of road construction in the hills, we were struck by the fact that quite often well known basic rules about engineering are not followed. Let me mention a few:

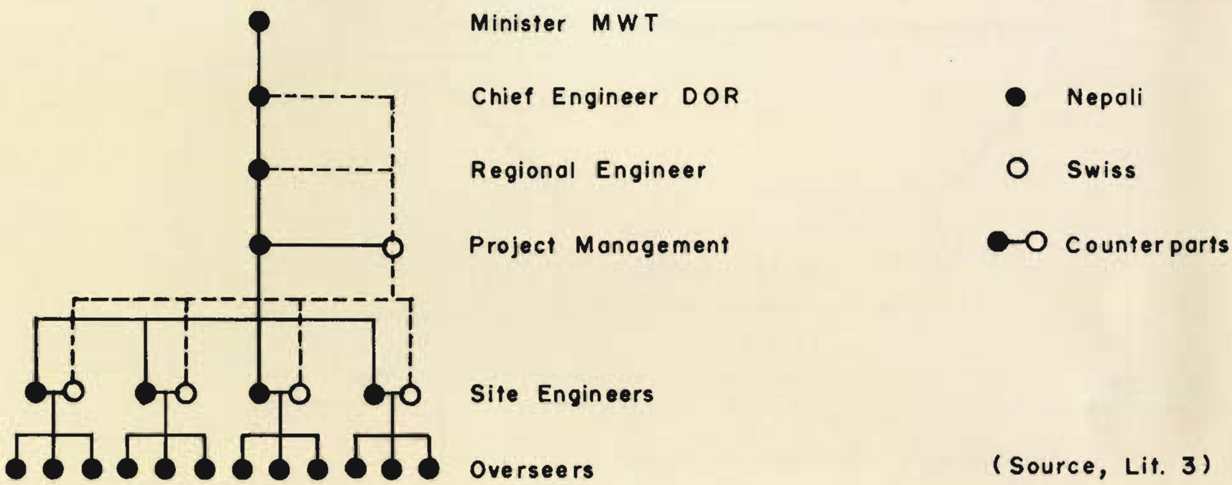
- o Survey and design should be given enough priority in the course of road construction. In normal cases, these activities swallow only about 10% of the total construction cost. This is almost negligible vis-a-vis the 90% construction cost. It should, therefore, be executed very carefully and thoroughly to guarantee the best possible alignment selection. Therefore, only very experienced experts in the fields of geology, road, and structure engineering are good enough for this task. Sloppily executed survey and design may easily result in a doubling of construction and maintenance cost as well as enormous environmental damage.

- o Erosion protection may often seem to be a foreign word and is not taken seriously enough. Compared to other road construction components it is rather cheap but has far reaching consequences in regard to environment stability and financial savings (maintenance). It is a continuous task from the construction stage throughout the road's life span.

- o The same is valid for maintenance. So far, maintenance is neglected badly in Nepal. This fact shortens the life span of a road enormously, with serious financial consequences and may even double the volume of investment for a given road network in a certain period. Maintenance, too, should start just after construction completion (preventive concept) and is a continuous task throughout the road's life span.

- o Considering the low priority given to maintenance, it would be justified to invest a bit more during the construction phase to minimise future maintenance cost. The overall investment (construction plus maintenance cost) will become smaller.

FIG. I COUNTERPART SYSTEM (JOINT DECISION TAKING)



(Source, Lit. 3)

FIG. 2 PROJECT ORGANISATION CHART IST PHASE

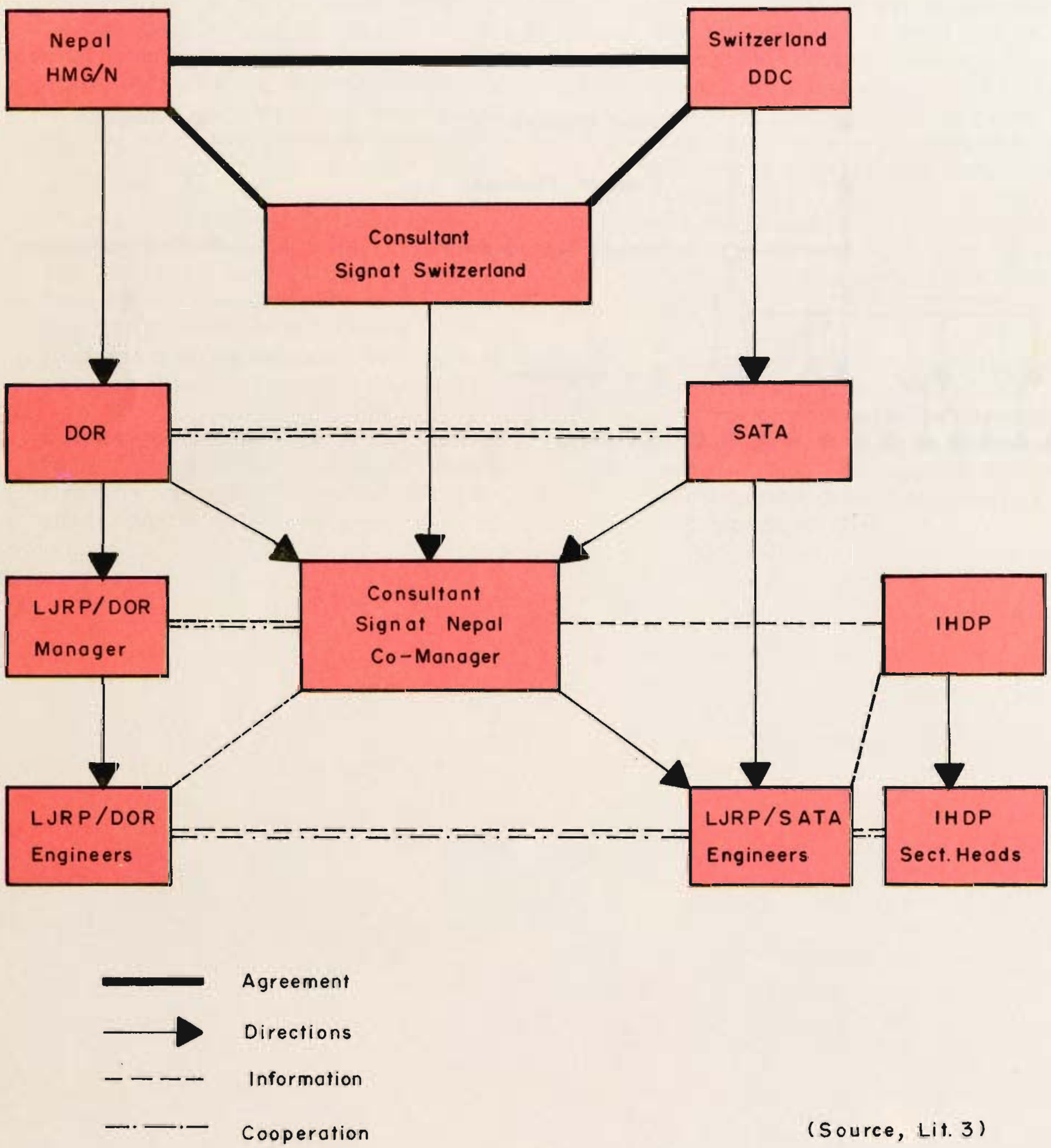


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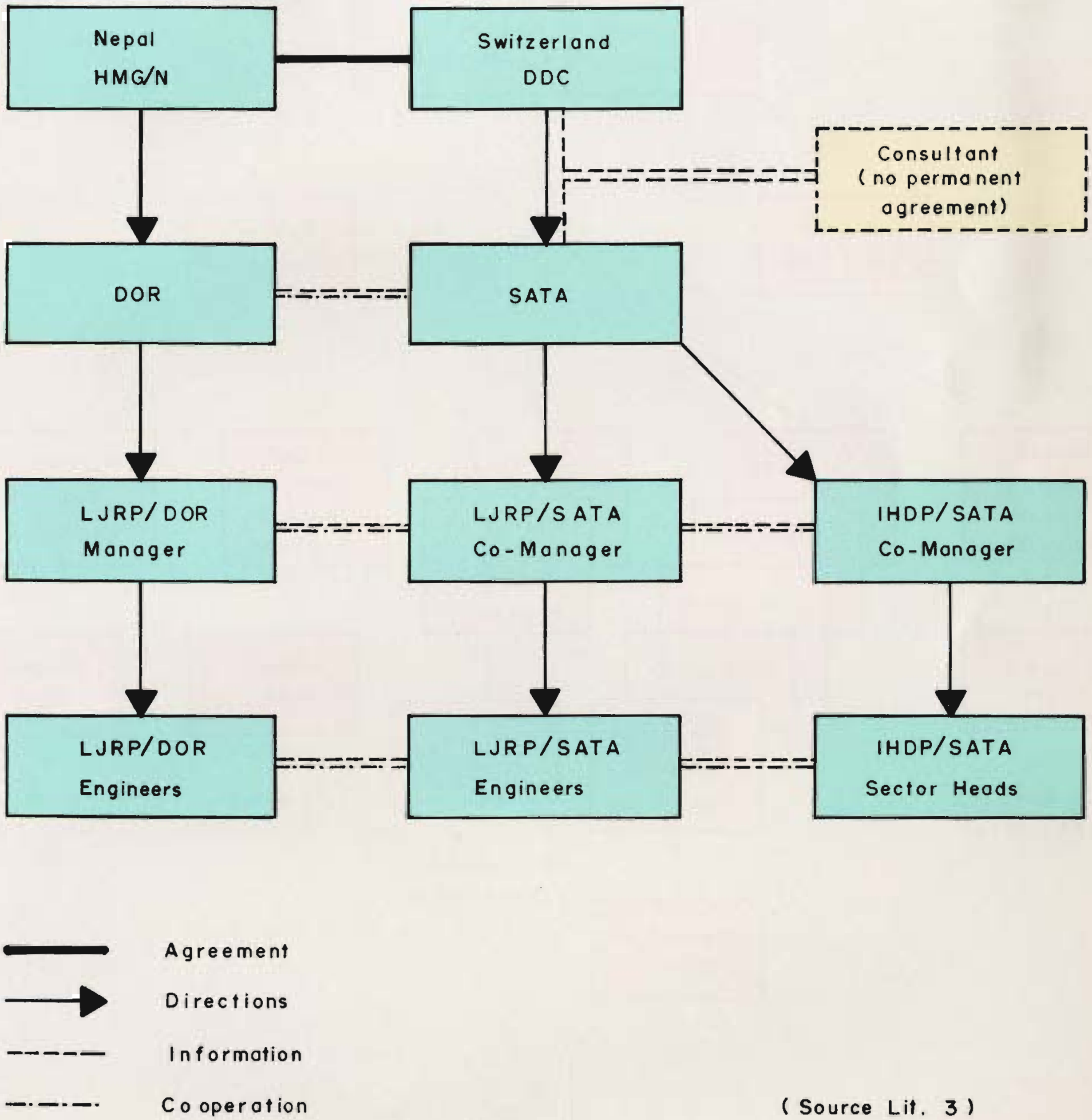
FIG. 3 PROJECT ORGANISATION CHART 2ND PHASE



(Source Lit. 3)

FIG. 4 ORGANISATIONAL STRUCTURE OF PROJECT

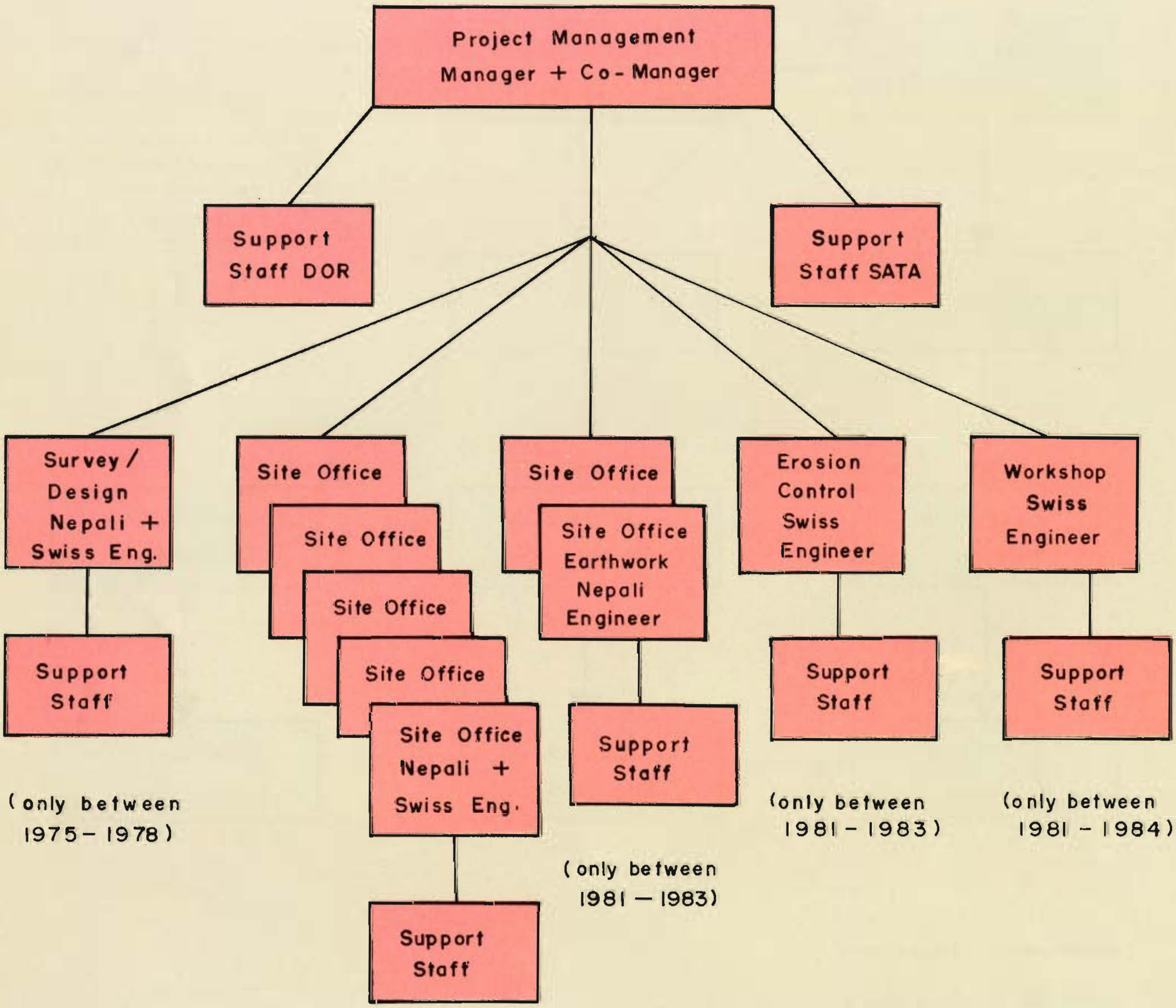


FIG. 5 ROAD BASE STANDARD SECTION

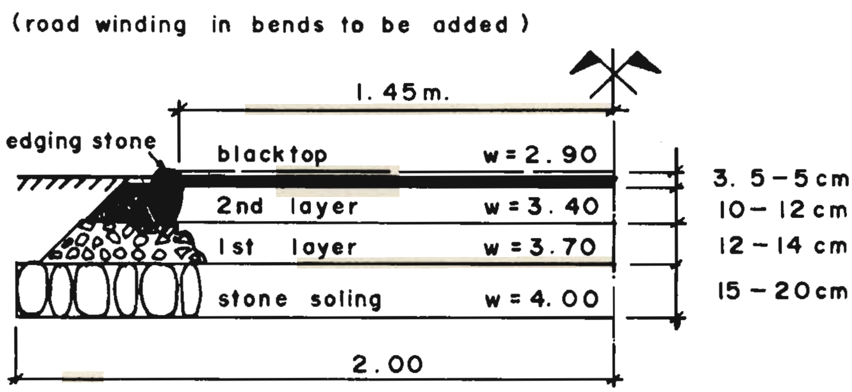
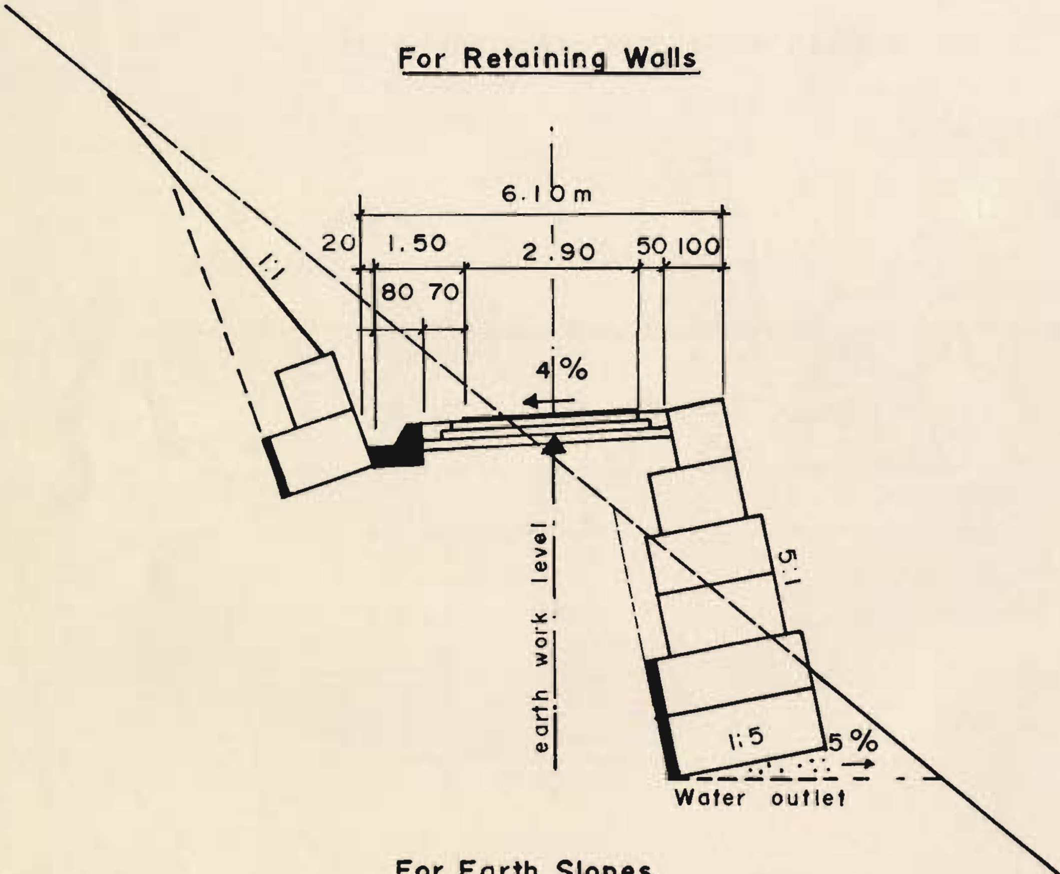


FIG. 6 STANDARD CROSS SECTION



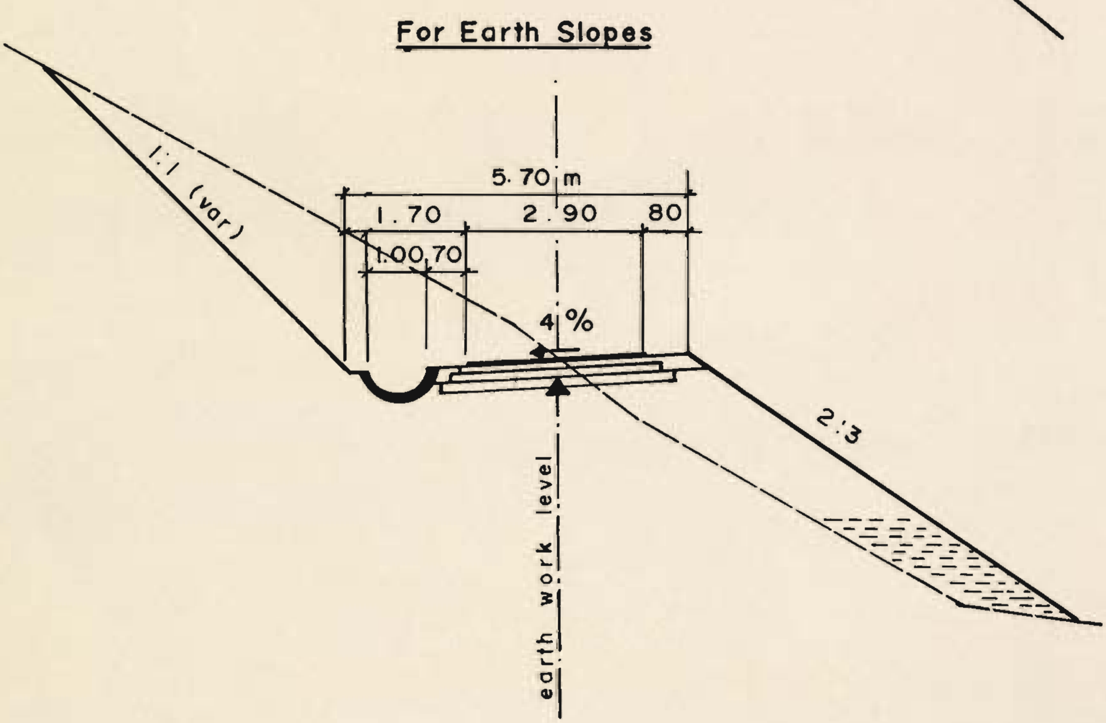
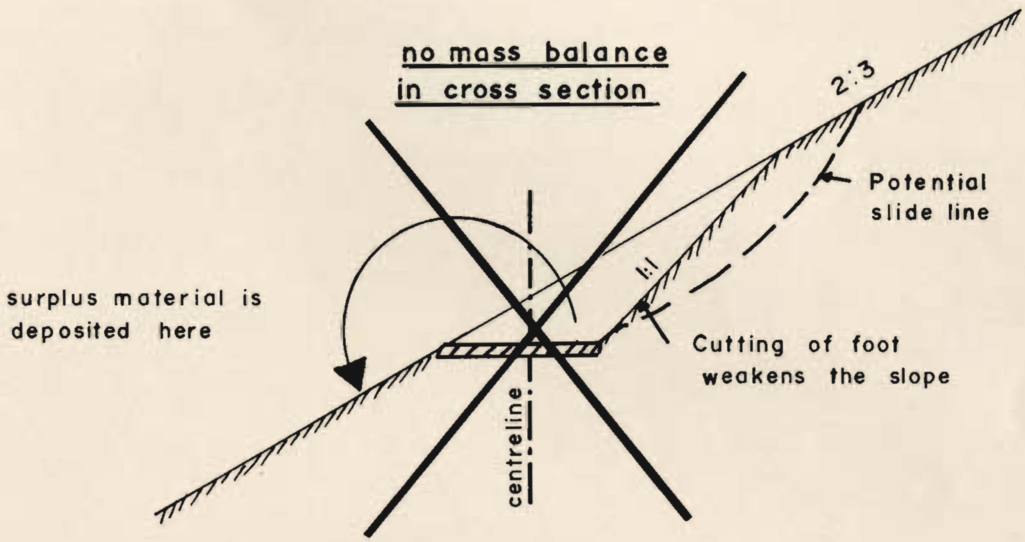


FIG. 7 FIXING OF CENTRELINE IN SLOPE



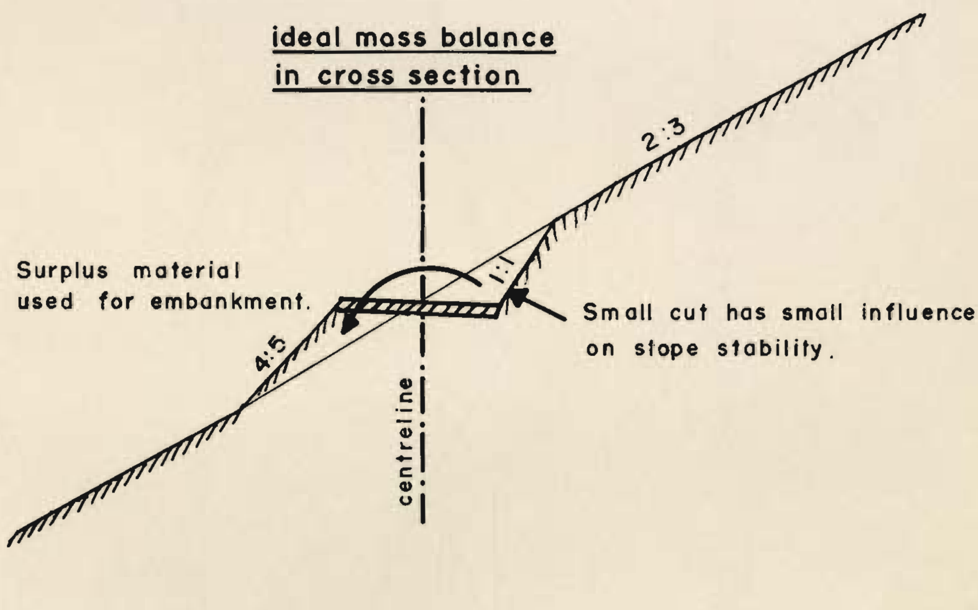


Fig. 8

FIG 8 LONG SECTION OF LAMOSANGU – JIRI ROAD

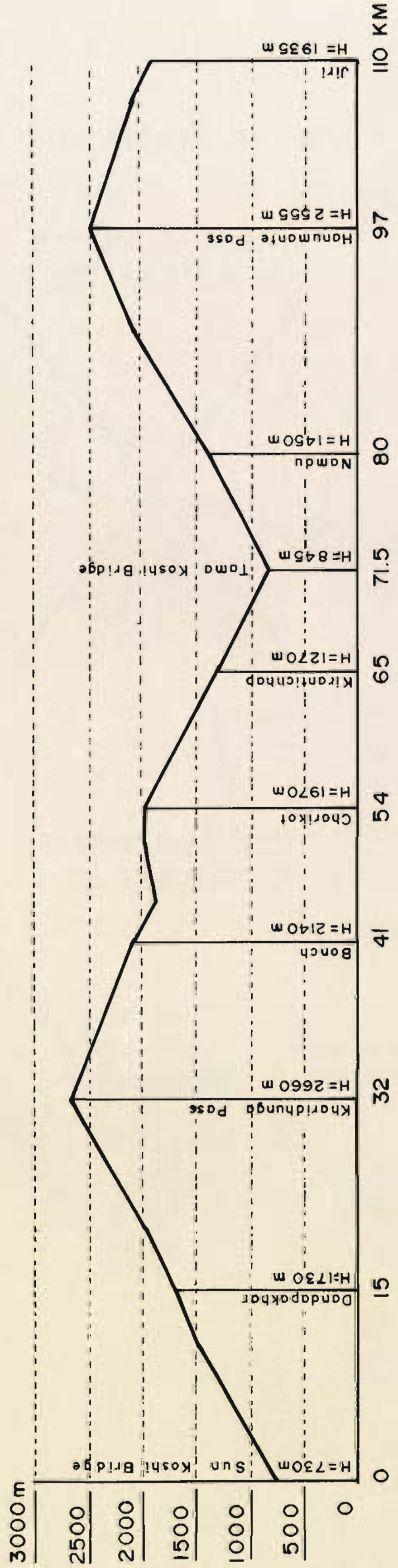


FIG. 9 SIDE DRAINS — STANDARD TYPES

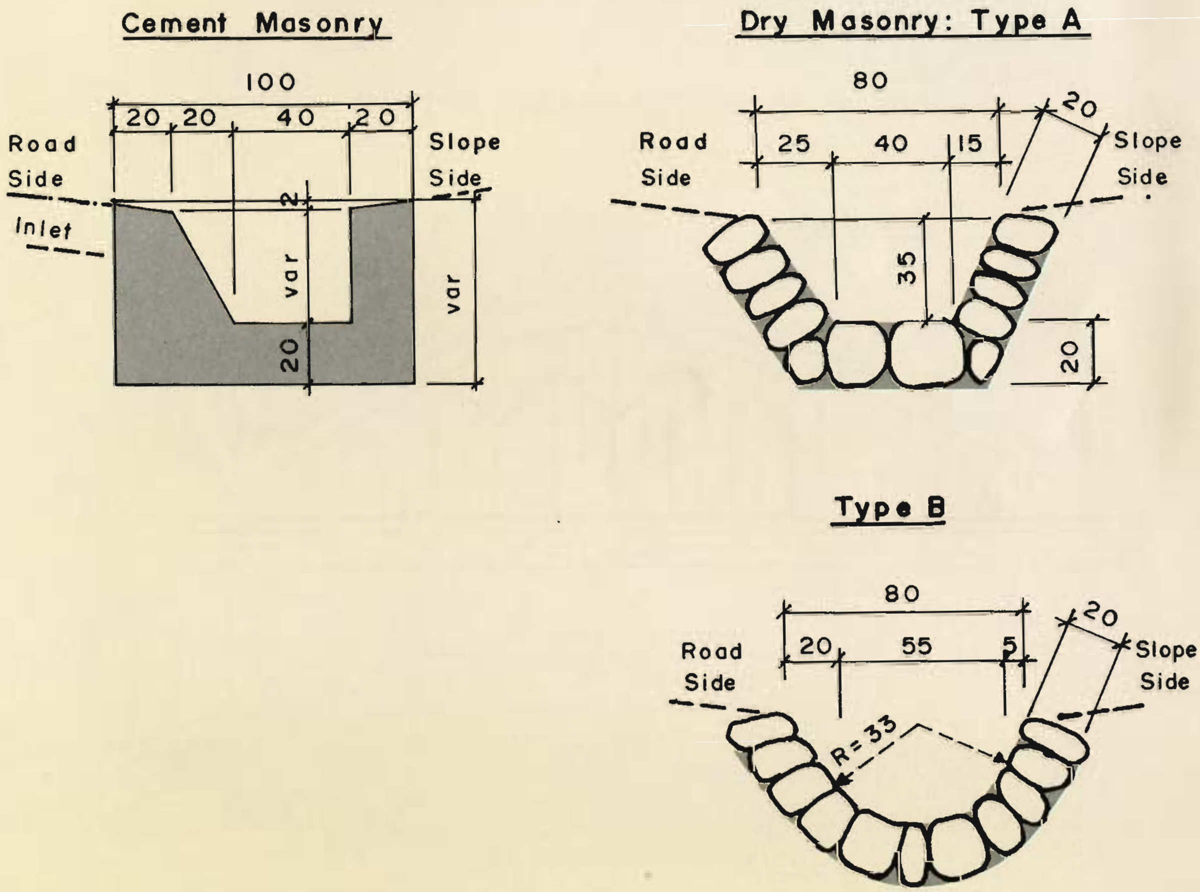


FIG. 10 SLOPE DRAINAGE SYSTEM

Situation

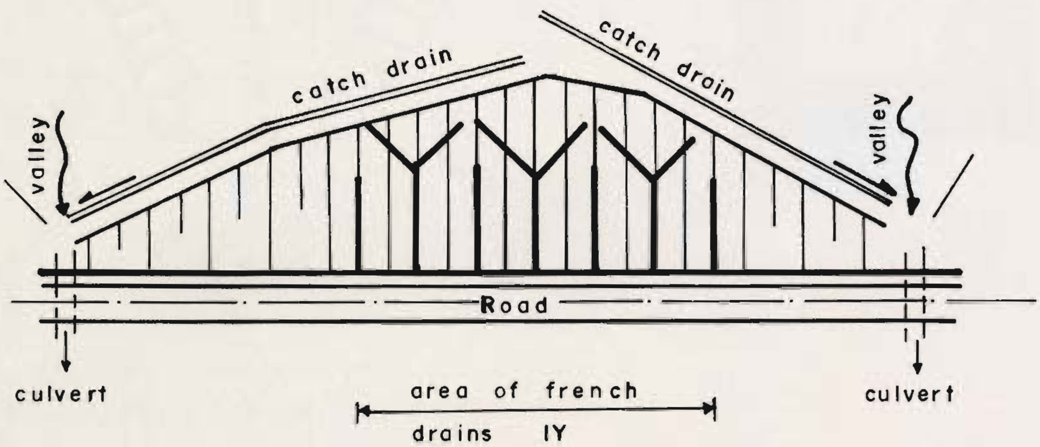
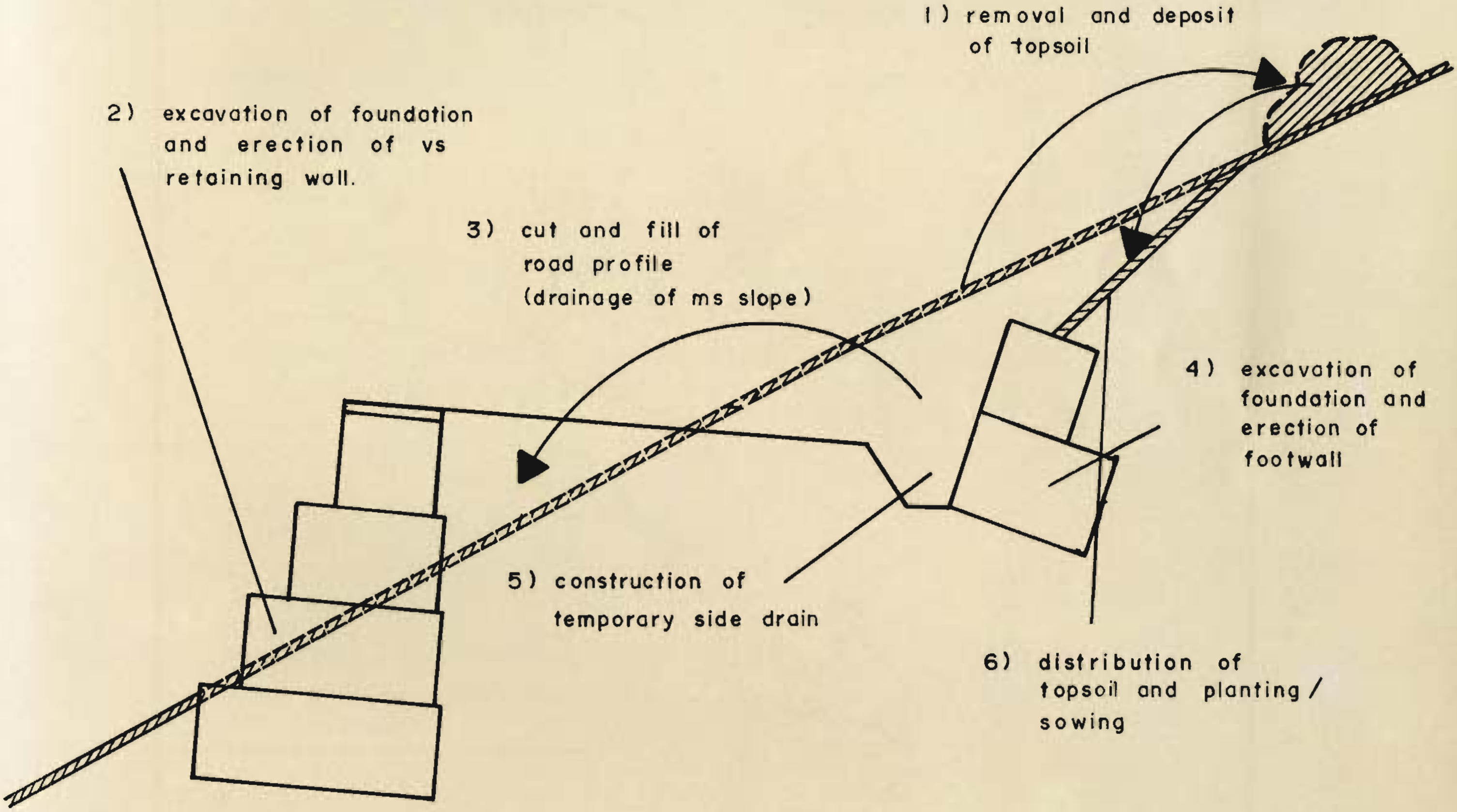
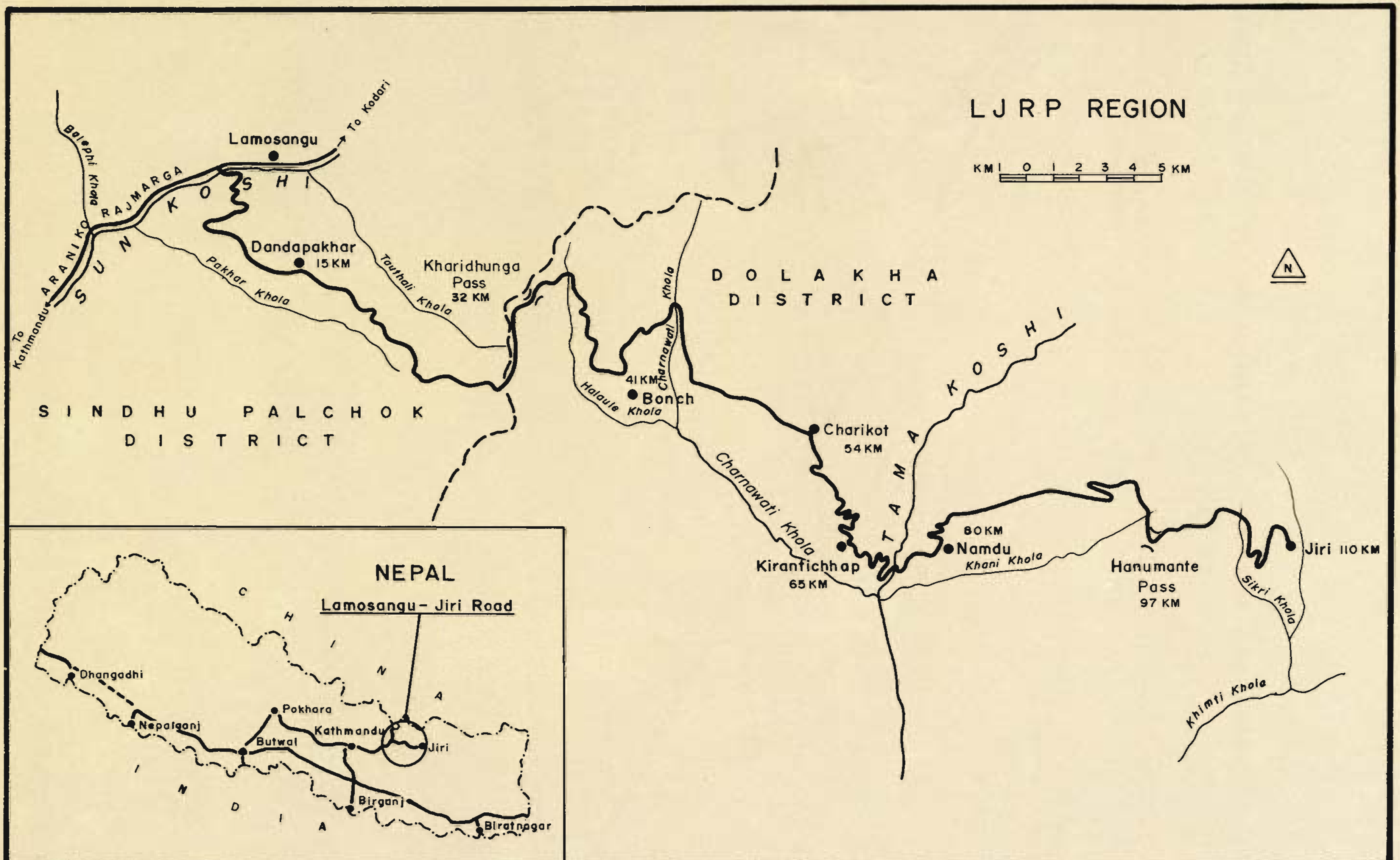


FIG. 11 RECOMMENDED SEQUENCE OF EARTHWORK STEPS WITHIN CROSS SECTION



MAP. I PROJECT . AREA



ICIMOD 1986 OCTO.

Project Cost and Construction Data (Construction phase)

Total length: 110 kms (Lamosangu - Jiri)

Construction start/end: March 1976/May 1985

Total project cost: NC 250 Million

(This amount does not include the expenses for the foreign experts)

The financing of the project is as follows:

- Switzerland	88.0 %	NC 220 million
- Nepal	9.5 %	NC 24 "
- WFP (partial investment of sales proceeds)	2.5 %	NC 6 "

The total cost can be split according to the different construction activities:

	%	NC per km	NC total
- Earthwork	30	0.69 million	75.9 million
- Water management/ erosion control	17	0.39 "	42.9 "
- Layerwork	12	0.27 "	29.7 "
- Blacktop	26	0.58 "	64.1 "
- Bridges/buildings/ equipment/maintenance/ administration	15	0.34 "	37.4 "
Total	100	2.27 "	250.0 "

On the other hand, it can be split according to labour, material and supervision:

	%	NC total
- Construction execution *	60	150.2 million
- Construction material **	19	46.7 "
- equipment	3	7.4 "
- Spare parts	2	5.6 "
- Engineering	2	4.6 "
- Administration	14	35.5 "
Total	100	250.0 "

* The following works and structures were executed:

- Earthwork	3,078,000 m^3
- Walls (gabion, cement and dry masonry)	371,000 m^3
- Culverts	526 nos
- Causeways	46 nos
- Hairpin bends	70 nos
- Major bridges (72 m span each)	2 nos
- Minor bridges (8-12 m span)	5 nos

** The following construction material was consumed:

- Cement	4,000 mt
- Gabion wire	2,200 mt
- Bitumen emulsion	3,700 mt
- Explosives	100 mt
- Gravel (stone soling/layerwork/blacktop)	190,000 mt

A very important question in the context of labour intensive road construction for the benefit of the local population is how much of the total investment went directly to the project region in the form of payments to labourers. In this connection, it is of specific interest to know that during our peak construction season (981/82) we had up to 9,000 labourers working at a time. The following figures show the overall money flow destinations (Lit. 3):

- Abroad	41 %	NC 103 million
- Kathmandu	27 %	NC 67 "
- Project area	32 %	NC 80 "
Total	100 %	NC 250 million

In other words, inspite of the labour intensive construction concept, only 1/3 of the total investment went directly into the project region and not even 2/3 to Nepal.

It is interesting to split these figures according to the type of construction work:

Type of Work	Abroad	Kathmandu	Project Area
- Earth work			
. big contracts	32 %	32 %	36 %
. piece contracts	30 %	20 %	50 %
- Water management	44 %	31 %	25 %
- Layer works	44 %	31 %	25 %
- Blacktop	60 %	24 %	16 %
- Bridges	70 %	10 %	20 %

The high figures for money flow abroad are to be explained mostly by the procurement of cement, gabion wire, explosives, and bitumen emulsion. It is, on the other hand, evident that the piece contract system gives the highest possible labour intensity. Very informative is the comparison of construction cost with other hillroad projects in Nepal (Lit. 9):

Project	Road type/ surface	Length	Construction period	Cost/km
Narayanghat-Muglin-Gorkha	2-lane/ paved	61 kms	1978-1981	NC 5.4 million
Dharan-Dhankuta	2-lane/ paved	51 kms	1976-1984	NC 8.4 "
Lamahi-Ghorai	1-lane/ gravel	26 kms	1976-1984	NC 2.2 "
Lamosangu-Jiri	1-lane/ paved	110 kms	1976-1985	NC 2.2 "

This comparison shows in real terms that the LJRP investment was the lowest per km investment inspite of its inclusion of a policy directed to: "Invest a bit more (construction phase) to benefit later on (maintenance phase)"!

Finally, a look back to the first cost estimate (1973) shows how this project has developed in terms of adaptation to changed circumstances and cost overrun:

- Initial cost estimate (1973)	NC 94 million
- Revised cost estimate (1980)	NC 225 million

The vast difference of NC 131 million (139% increase) was due to the following:

. increase in road length by 5 kms	NC 4.5 million
. increase in road width by 0.6-1.0 m	NC 14.7 "
. inflation and running fixed cost between 1973 and 1985	NC 43.6 "
. inclusion of Sun Kosi Bridge	NC 3.6 "
. large scale erosion protection work	NC 7.7 "
. inclusion of blacktopping of section km 0-71.5	NC 41.5 "
. reinforcement of road base between Lamosangu and Kharidhunga due to mine	NC 4.9 "
. land compensation along the entire road length	NC 7.7 "
. maintenance of completed road sections till 1985	NC 2.8 "
Total	NC 131.0 "

- Construction cost	NC 250 million

The difference of NC 25 million (11% increase) against the revised cost estimate was mainly due to:

. inclusion of blacktopping of section km 71.5 - 110	NC 25 million

APPENDIX II

First Visible Impact of the Road

During the construction the discussion among the Swiss concerned with technical cooperation activities never stopped as to whether the impact of the road should be judged as being in general more negative than positive, an opinion which was strongly nourished by the publication of the book "Nepal in Crisis" (Lit. 10).

To get answers to this crucial aspect, as well as to many other open questions concerning impact of the IHDP, the DDC decided to conduct an impact monitoring study for both the projects. This study started in 1986 and will last for 10 years.

But it is already today possible to give a few definite answers which can roughly be divided into two impact groups:

- Positive visible impact:

  . Substantial income has been generated,
  . Construction activities along the road have been enormously increased (shops, teashops, lodges, workshops, etc.),
  . Basic consumer goods like kerosene, sugar, salt, are cheaper than before,
  . The project region became much more attractive for government officials (e.g. teachers, doctors) due to the improved communication with Kathmandu,
  . Services have been increased,
  . The present road traffic volume is already twice as large as estimated.

- Impact with side effects on environment:

  . The remaining forests of the area are now more endangered by the easy road access,
  . The LJR has become the basis of some local access roads to adjoining regions,
  . The exploitation of the magnesite mine at Kharidhunga became feasible and is in full swing today.

It is evident, that depending on the angle from which one looks at it, positive impact may have negative aspects and vice versa (e.g. the easy road access to the forests could be used as the basis of the implementation of a forest management system).

BIBLIOGRAPHY

REFERENCES:

Educational Enterprise Pvt. Ltd., Kathmandu.
1984 *"School Atlas of Nepal"*, January, by Dr. R. K. Shrestha, I. Shrestha, and S. H. Shrestha.

Helvetas/STC/ITECO.
1984 *"The Principal Geological Factors Leading to Landslides in the Foothills of Nepal. A Statistical Study of 100 Landslides. Steps for Mapping the Risks of Landslides"*, by A. Wagner.

HMG/N, MWT, DOR.
1985 *"SAARC-Seminar on Rural Roads"*, June.

HMG/N, SATA.
1984 *"Rural Road Construction in Nepal, Evaluation of Experiences from Lamosangu-Jiri Road Project"*, April, by W. Kappeler.

IHDP.
1986 *"Meteorology 1985"*, August, by the Water Management Section.

LJRP.
1985 *"Review of Experiences from the Construction of the Lamosangu-Jiri Road"*, June, by U. Schaffner.

1982 *"Blacktop km 71.5-110 from Tama Kosi-Jiri"*, 15 July.

Oxford University Press, Delhi.
1980 *"Nepal in Crisis"*, by P.M. Blaikie, J. Cameron, J. D. Seddon.

SATA.
1971 *"Road Feasibility Study"*, August, by R. Schmid, A. Hartmann, R. Zemp.

Swiss Government.
1974 *"Botschaft des Bundesrates an die Bundesversammlung betreffend die Vereinbarung ueber Finanzhilfe an Nepal"*, 15 May.

SELECTED BIBLIOGRAPHY:

Adhikary, N. P.
1975 *Economic Impact of Mahendra Rajmarg (Eastern Sector)*, Kathmandu.

Asian Development Bank.
1986 *Technical Assistance to the Kingdom of Nepal for Transport Sector Profile*, May.

____
1972 *Appraisal of Hitauda-Narayangarh Road Project in Nepal.*

____
1981 *Feeder Roads Improvement Projects.*

Adhikary, M. R.
1985 *Institutional Framework for Rural Roads Execution*: Paper Presented on SARC seminar on 1985 Rural Roads, Kathmandu, June.

Agrawal, B. L.
1985 *Priority Determination for Rural Roads.* Paper Presented at SARC Seminar on Rural Roads, 1985 Kathmandu, June.

Allal, M. and Edmonds, G. A.
1977 *Manual on the Planning of Labour - Intensive Road Construction*, ILO/Geneva.

Ayyar, D. A. S.
1973 *A Brief Note on the Construction of Siddhartha Rajmarg, Kathmandu.*

Balberine, B. C., Jenkin, R. N., and Collin, S.
1977 *Report of Reconnaissance Mission*, Background Information Prepared for KHARDEP Project.

____
1977 *Report of Reconnaissance Mission 1976*, prepared for KHARDEP (proposals) submitted to ODA.

Beyer, John. and Beenhakker, Arie
1970 *Economic Evaluation of the Patan-Kirtipur Bridge Kathmandu.*

Blaikie, Piers and others
1975 *Road Provision and the Changing Role of Towns in West-Central Nepal*, Paper Presented to the Indo-British Seminar.

____
1976 *The Effects of Roads in West-Central Nepal*, Vol. I, II & III, Overseas Development Group, University of East Anglia, ESCOR, Ministry of Overseas Development, May.

Boch, Isaacson. and Joel, M.
The Rural Development Construction Management Manual Prepared by HMG/USAID with Assistance from PADCO for Rapti Integrated Rural Development Project.

Bodenmann, H. J.
1971 *Breickenbau Inder Extension von Dhorpatan* Report Field Trip.

CEDA.
1973 *Comparison of Different Road Projects from the Point of View of Indirect Benefits.*

____
1974 *The Chinese Road Construction Technology: Work Elements of Activities.*

____
1978 *Seminar on Road Planning and Road Construction in Nepal.*

____
1973 *Comparative Evaluation of Road Construction Techniques in Nepal*:
Part I - Summary and Recommendations
Part II - Information and Analytical Framework
Part III - Data, Results and Conclusion
Part IV - Appendix

Transport Seminar Reading Materials, Kathmandu: List of Contents
Mr. G. S. Glaister "*Highway Maintenance*"
Mr. J. P. Upadhaya, "*Use of (Foreign) Consultants in Projects Development*"
Mr. Bharat B. Pradhan, "*Strengthening the Planning Cells in the Ministry of Works and Transport, Transport Communication*"

Comtec, in Collaboration with Alpania, and Macchi.
1970-75 *UN-HMG, Nepal Road Feasibility Study*
- Project No. 1 - East-West Highway - Ilam
- Project No. 2 - East-West Highway - Bhadrapur
- Project No. 3 - Section 3a- Dharan Bazar-Dhankuta
  Section 3b Mulghat Tehrathum
  Section 3c - Mayaghat - Phidim
- Project No. 4 - Section 4a- E-N-Highway Nepaltar
  Section 4b - Nepaltar-Udaipurgarh
- Project No. 5 - E-W-Highway Sisha
- Project No. 6 - Section 6a - E-W Highway Sindhuli Bazar
  Section 6b - Sindhuli Bazar - Nabughat

1974 *UN/HNG Road Feasibility Study for the Kathmandu-Birgunj Corridor*
- Report
- Appendix A - Price Analysis
- Appendix B - Soil Laboratory Test
- Appendix C - Computer Tabulations
- Drawings

Chaudhary, N.D.A.
1967 "*Preliminary Report on Priority of Feeder Roads in Nepal*" Bangkok, Asian Highway Transport Technical Bureau, ESCAP.

China, People's Republic of
1986 *Pokhara-Baglung Road Project: Design Report & Drawings*, Submitted to Dept. of Roads, May.

Crown Agents (Doc. No. T. 119-3).
Outline Training Documents for HMG/N 3rd Highway Project, Prepared by J. D. Thacker, Training Manager.

Cox, J. B.
1976 *A Comparison between the Bankleman Beam and CBR Pavement Design Method for a Rural Road in Nepal.* Proceedings, First Conference of Road Engineering Association of Asia and Australia.

Cox, J. B., and Koirala, N.P.
1974 *Pavement Design Report*, *Hetauda-Narayangarh Highway Project: Technical Memorandum* B-3, N. D. Lea & Associate.

Cusack, Vernon, V.
1967 *Nepal Road Development Project Completion Report* 1963-1966, AID/N.

Dangal, M. K.
1985 "*Optimum Design of Rural Roads: A New Prospect*" Paper presented at SARC Seminar on Rural Roads, Kathmandu, June.

Delcanda Int. Ltd. and Roy Jorgensen Ass.
1978a *Roads Department Support Services Project: Interim Report*, Prepared for HMG, Nepal and Canadian International Development Agency, October.

______ 1979b *Roads Department Support Services Project: Equipment Management Manual*, Prepared for HMG, Nepal and CIDA, September.

______ 1979c *Roads Department Support Services Project: Road Maintenance Management System Manual*, Prepared for HMG, Nepal and CIDA, August.

Deoja, B. B.
1985 "*Consideration for Rural Hill Roads in Nepal*" Paper Presented at SARC Seminar on Rural Roads, Kathmandu, June.

Dhungana, Bhawani and Others
1978 *A Case Study of Hetauda-Narayangarh Section of East-West Highway, Mahendra Rajmarga, Instruction Manual* (Mimeo) CEDA.

Edmond, G., and Rudd, Olav.
1984 *Labour Based Construction and Maintenance, Some Indicators of Viability: Criteria for the Choice of Technology*, ILO, Geneva, October.

Edmond, G. A.
1975 *The Role of Design in the Choice of Road Construction Techniques*, ILO, Geneva, February.

______ *A Framework for Data Collection on Road Construction: Parameters Data Sampling, Methodology*, ILO.

ELC Electroconsult.
1969 *Feasibility Study Improvements to Mahendra Rajmarga, Hetauda-Narayangarh Section*, October.

Enden, Garry Peter.
1980 *The Development of Road Transportation in Nepal and its Relationship to Agricultural Development*, Cornell.

ESCAP.
1979 *ESCAP Transport and Communication Decision, Design Highway Network in Nepal*, Jan. 22.

______ 1983 *Report of ESCAP Mission of Transport Experts on Integrated Transport Systems for Nepal*, (ESCAP/UN, Bangkok) July.

______ 1972 *Seminar-cum-Training Course on Evaluation of Transport Prospects*, At Head of Hill, Bangkok, Nepal- p. 200-204.

______ 1980 *Study on Rural Roads: Construction and Maintenance Draft Report*, May.

Everitt, Martin C.
1982 *Supplementary Geotechnical Reconnaissance Report, Sallyan, Lewang and Pyuthan Roads*, USDA, Forestry Service, Rockey Mountain Region.

______
1981a *Geotechnical Reconnaissance Report, Tulsipur-Sallyan Road*, USDA, Forest Service, Rocky Mountain Region.

______
1983b *Final Project Evaluation Report: Landslide and Social Stabiization Project for Western Hill Road, Dhangarhi-Dandeldhura*, USAID.

Eugene, Kojan.
1978 *Engineering-Geologic Evaluation of Landslide Problems: Western Hills Road Project, Godavari to Dandeldhura, Nepal*. June.

Finne, Grace W.
1973a *Nepal: Economic Feasibility Analysis of the Surkhet Road Project Based on Preliminary Engineering Cost Estimates.* Dept. of Transportation, World Bank.

______
1973b *Working Paper on The Western Hills Roads Project*, AID/N.

FAO (Nep/80/029).
1985 *Landslides Prevention and Contro*l, HMG/UNDP/FAO, Kathmandu.

FAO.
1984 *Shivapuri Watershed Management and Fuelwood Plantation Project: Plan of Operation*, FAO, November.

______
1970 *Road Survey Thansing to Kathmandu*, Ministry of Forest, FAO/UNDP, Kathmandu

______
1972 *Hill Area Transport Development Request to the UN/FAO, WFP for Assistance in a Project for Economic and Social Development*, HMG.

Gallagher, John S.
1968 *Comments and Observation Upon Completion of my Assignment in Nepal* Project NEP/08/001 UNDP.

Glaister, C. S.
1967 *A 20 Year Highway Plan for Nepal 2022-2041* (1964-1984).

______
1973 *Nepal Road Feasibility Study*, NEP/69/516: *Birgunj Corridor Study, Review of Draft Final Report, Project Manager's Report on Review Meeting*, October.

Gauff Associates (FRG).
1971 *Feasibility Study for Improvement of Hetauda-Narayanghat Road for Dept. of Roads*, February 1971

Goil, R.M.
1971 *A Study of The General Economic Impact of Siddhartha Rajmarg*, Indian Cooperation Mission

Guerin, L.
1980 *Interregional Project for Planning and Administration of Special Public Programme: Tools, Equipment and Local Materials for Special Labour Intensive Public Works Schemes in India, The Philippines, Tanzania and Tunisia*, ILO, Geneva.

Gupta, S. P.
1962 "*Report on Kathmandu-Janakpur Road*: Banepa, Regional Transportation Organization"

Haering, Barbara.
1980 *Jiri Road - Jir Tomorrow*? Impact of the New Lamosangu-Jiri Road, Aims and Possibilities of Physical Planning, Zurich

Hansen, Joakin.
1986 *Consultancy On Road Design Planning and Construction.* Report Prepared by UNDP/FAO for Shivapuri Watershed Management Fuelwood Project, HMG, Ministry of Forest & Soil Conservation.

Harder, Willi.
1977 *Strassenbrucken in Nepal, Lamosangu Jiri Road Project*, ETH, Zurich, INDEL.

Hartman, A.
1971 *Forest Road Project, Likhu Khola - Thadi - Pokhara - Jumla Roads.*

Henley, J. M.
1980 *Report on The Construction of Dhankuta-Hill Road*, Prepared for Scott Wilson Kirkpatrick & Partners.

Henrich, R.
1977 *Mountain Roads, Consultant Report NEP/74/02*, FAO, Kathmandu.

HMG Department of Food and Agriculture.
1979 *A Socio-Economic Benchmark Study of The Area Around the Prithvi Highway*, Dept. of Food and Agriculture Marketing Service, Kathmandu, December.

HMG. Ministry of Finance.
1978 *Document Prepared for Nepal AID Group Meeting to be held in Paris in May.*

HMG. Department of Roads.
1973 *Economic Feasibility Study of Improved Thankot-Naubise Road.*

HMG. Ministry of Works and Transport.
1972 *Transport Development in Nepal : A Country Paper.*

Hoskins-Western-Sonderegger Inc.
1973/74 *Engineering Evaluation Western Hills Highway Project with Comments on Nepalgunj-Surkhet Highway.*

IBRD.
1965. *"A National Transport System for Nepal"* Vol. I to III, Washington D. C. World Bank.

____
1970 *Appraisal of a Highway Project in Nepal*, Transportation Project Dept. Washington D. C. October 27, 1970. Report No. PTR-54a.

____
1984 *Staff Appraisal Report Nepal, Third Highway Project*, Report No. 4763-NEP, Power & Transportation Division, South Asia Projects Dept. World Bank, August 9.

____
Nepal Second Highway Project Supervision Review Reports.

____
1977 *Project Completion Report, Nepal First Highway Project* (Cr. 223-NEP) September.

———————
1979 *Nepal 1979 Economic Mission Back-to-Office Report and Supporting Work Paper*, July 9.

———————
1973 Documentation of IBRD/IDA (Asia Region/South Asia Dept.) Report No. 125a-NEP, *Economic Situation and Prospects of Nepal*, August 15. Sector Annex:
I. Agriculture
II. Education
III. Industry
IV. Population and Family Planning
V. Power
VI. Transport

IBRD (South Asia Regional Office)
1986 *Project Completion Report: Nepal Highway Project* (Credit 730 NEP) Report No. 6296, June 20.

ILO.
Road Construction and Maintenance: Choice of Technology in Developing Countries.

———————
Nepal Special Labours, Intensive Public Works Programme: Economic Feasibility Study of the Dandeldhura-Doti Road, ILO/UNDP/HMG.

ILO/DIHM/MPLD
1981 *Report on Popular Participation in the Programme of Nepal*: Special Labour Intensive Public Works Programme, February.

Indian Cooperation Mission.
1969 *Indian Cooperation Mission: Mahendra Rajmarga.*

International Engineering Consultant Association (Japan).
1983 *The Kingdom of Nepal, Report on Present Transportation Infrastructure in Nepal*, January 1984. Subsidiary Project by Japan Shipbuilding Industry Foundation

International Development Centre of Japan.
1979 *Current Status and Development Prospects of Transport Sector in Nepal*, November.

Integrated Development System.
1983 *Roads and Surface Drainage Maintenance in Urban Centre of Nepal.* Commissioned by German Agency for Technical Cooperation (GTZ) under Technical Cooperation with Bhaktapur Development Project.

ITECO
1985 *Feasibility Study for the Transportation of Limestone Quarry, The River Trisuli Near Majhimtar-Jogimara, Nepal*, Report for FAO, September.

Ives, J. D. and Messerli, B.
1983 *Mountain Hazards in Nepal: Introduction to an Applied Mountain Research Project*, Mountain Research & Development, Vol. I.

JICA.
Report on the Preliminary Design Transportation Improvement Project in The Kingdom of Nepal: Japan International Cooperation Agency.

Kappeler, W.
1983 *Rural Road Construction in Nepal, Experience and Evaluation of Lamosangu-Jiri Road Project*, SATA.

Kehrli and Niederhausen.
1979 *Nepal: Lamosangu-Jiri Strasse Rapport des Nepal Besuches*, Signat Ag.

Kienholz, H.
1985 *Mountain Hazards Mapping in Nepal: Kathmandu-Kakani Area*, Geographica Bernensia, Switzerland.

Khan, M. Izaz.
1985 "*Rural Roads in Pakistan - Design, Construction, Agencies for Execution and Funding*", Country Paper of Pakistan to SARC Seminar on Rural Roads, in Kathmandu, June.

Khaire, V. A.
1975 *Sonauli-Pokhara Road roject in Nepal*, Indian Road Congress XXXV-4 Paper 298, p.725-835.

Kojan, Eugene.
1978 *Western Hills Road Project: Godavari - Dandeldhura Nepal*, US Forest Service.

Lama and Pemba, (East Consult).
1985 "*Location of a Low Volume Road in Hills" My Experience*, Paper Presented at SARC Seminar on Rural Roads, Kathmandu, June.

Lamosangu-Jiri Road Project.
1983 *Unterhaltskonzept-Entwurf*, SATA.

____
1978 *2 Drafts of the Road Maintenance Concept for the Lamosangu-Jiri Road Project*, SATA.

____
1985 *Review of Experience from the Construction of Lamosangu-Jiri Road.* SARC Seminar on Rural Roads, Kathmandu, June.

____
Geotechnical and Engineering Report on Possible Alignments for the Dhankuta-Hile Road, Working Paper 88, Crowthorne Berkshire: Transport and Research Laboratory, Overseas Unit

Maleka, M. E.
1985 *Problems in Maintenance and Its Remedies in Nepal* Paper Prepared at SARC Seminar on Rural Roads, Kathmandu, June.

Mehta, R. R.
1978 *Technical Instructions, Vol. I, Standard Design of Rural Earth and Gravel Roads*, ILO, Geneva, January.

Mathur, Tej.
1979 *Recommendations for Stabilization of Road, Dhangarhi Dandeldhura Highway Prject* (Western Hills Road), US Forestry Service.

Marsh, D.K.V.
The Effect of the Opening of the Dharan-Dhankuta Road on the Movement of Goods and People in the Koshi Hills, Report No. 41.

Moise, Allal.
1975 *Selection of Road Projects and the Identification of the Appropriate Road Construction Technology*: General Consideration, ILO, Geneva, February.

Oldier, L., Millard, R. S., Pemintal Des Saito., and Memra, S.A.
1967 *Low Cost Road Design, Construction and Maintenance under Responsibility of UNESCO.*

Overseas Development Agency (ODA).
1986 "*Nepal Sector Road Paper*" Prepared by ODA, South East Asia Development Division, Bangkok, April.

N.D. Lea and Associates. Canada
1983 *Preliminary Engineering Report for Proposed Improvement of*:
A. Selected Bridges Between Kathmandu-Raxaul
B. Pavement Between Naubise-Mugling
C. Road Works Report to Department of Roads, HMG, Nepal.

____
1976 *Mahendra Rajmarga-Tulsipur Road Project Phase I Review of Feasibility Study*, Phase II Consolidated Technical Report. Nepal/Canada, March and November.

N.D. Lea & Associates, Canada.
1976 *Consolidated Technical Report on Mahendra Rajmarga, Tulsipur Road Project*, HMG.

Niese, William.
1970 *End of Tour Report of William Niese*, AID/N.

Nyachhyon, B.L.
1985 "*Rural Roads: Planning Dilemma*" Paper Presented at SARC Seminar on Rural Roads, Kathmandu, June.

Raj, P. A.
1978 *Road to The Chinese Border*, Foreign Affairs Journal Publication, Kathmandu.

Raaje, D.
1985 *Country Paper of Department of Public Works & Labour*, at SARC Seminar on Rural Roads, in Kathmandu, June.

Rahaman, and Shaikh Fazlur.
1985 *Rural Roads in Bangladesh*, Country Paper Presented by Bangladesh at SARC Seminar on Rural Roads held in Kathmandu, June.

Rana, S. J. B.
1971 *An Economic Study of The Area Around The Alignment of the Dhangadi-Dandeldhura Road*, CEDA Study Series.

Reiger, H. C., Bieue, F., Goldschdt, W., Steiger, J.
1976 *Himalayan Ecosystem Research Mission*, Nepal Report, Heidelberg, August.

Roughter & Partners
1985 *Pavement Evaluation, East-West Highway: Dharan-Dhankuta Road Project* Submitted to ODA, January.

Sadani.
1967 *Study on the Order of Priorities for Highway Construction in Nepal.* United Nations.

Schaffner, Urs.
1978 *Schlussbericht - Lamosangu Jiri Strasse.*

Schmid, Robert.
1971 *Working Programme for the Rural Feasibility Study in Dolakha and Ramechhap Districts*, SATA.

———
1969 *Zur Wirtschaffsgeographic von Nepal Transport und Kommunikations Problems Ostrepals im Zusammenhang mit der Schwezerischen. Entwidklung shilfe in der region Jiri*, SATA.

———
1973 *Road Alignment Alternatives, Assessment of Decision between West East or South North Alternatives*, STC/Berne.

Schmid, Robert, Hartman, Armand, and Zemp Robert
1971 *Road Feasibility Study of Tama Koshi-Khimti Khola Area, Economic Aspects, Technical Aspects*, SATA.

Scott Wilson Kirkpatrick and Partners.
1980 *Report on the Construction of the Dhankuta to Hile Road for KHARDEP* July.

Shrestha, B. K.
1985 *Peoples Participation In Rural Roads Construction in Nepal,* Paper Presented at SARC Seminar on Rural Roads, Kathmandu, June.

Shrestha M. M.
1985 "*Rural Roads*", Paper Presented at SARC Seminar on Rural Roads, Kathmandu, June.

Shrestha, Nirmal Das
1967 *A Comparative Study of Tribhuvan Rajpath and Kodari Rajmarg*, Kathmandu.

Shrestha, R.L.
1980 *Impact of Kathmandu Raxaul Highway (Tribhuvan Rajmarg) on Nepalese Economy.*

Signat Ag.
1975 *Lamosangu-Jiri Road Project*, Report on Technical Visit of June.

———
1977 *Lamosangu-Jiri Road Project*, Geological Report No. 1, 2 and 3.

———
1979 *Report Based on the Visit by W. Kehrli Ing. ETH and P. Niederlauser* Dipl. Eng ETH/ASIC in Kathmandu and Inspection of Site Between February 14-26.

Sorber, J. H. C.
1968 *Dharan-Dhankuta Motorable Road Under Construction*, Public Works Department.

Spindler, Alf de.
1950 *Bhimphedi-Kathmandu Road Project*, SPIT/Switzerland.

Stieger, Cecile.
1972 *Wage und Landschaft in Gebiet der Projektierten: Lamosangu-Jiri-Throse Strasse*, SATA, October.

Swiss Association for Technical Assistance (SATA)
1977 *Technical Training Documentation*
- Soil Mechanics
- Soil Investigation
- September

———
1971 *Road Feasibility Study of Tamakoshi-Khimti Khola Area, Eastern Nepal*
Part I : Economic Aspects by Schmid R. & Others
Part II : Technical Aspects by Hartman A. & Others

———— 1983 *Unterhelts Konzept, Lamosangu-Jiri Road Project.*

Taylor, G. A.
Roads Sector: An Approximate Method for Sizing of Culverts, KHARDEP Report. 39.

———— 1982 *Summary of Basic Costs Applicable to The Koshi Hills,* KHARDEP Report No. 33.

———— 1982 *An Examination of The Costs of The Dhankuta-Hile Road,* KHARDEP Report No. 36.

UNDP/ESCAP.
1985 *Rural Road Construction and Maintenance Report of a Seminar-cum Study Tour to China,* 7-20 September. Vols. I & II.

UNDP (Special Fund).
1970 *Plan of Operation: Nepal Road Feasibility Studies,* Kathmandu.

UNDP/UNCTAD.
Transport Problems of Landlocked Countries, The Case of Nepal.

USAID.
1966 *The Hill Roads Project, Kathmandu.*

———— 1967 *Dhangarhi-Dandeldhura Road Project, Formulation and Evaluation,* Kathmandu.

———— 1973 Human Resources Development Division.
A Study of Human and Economic Problems Related to the Overland Transportation Sector in Nepal.

Wangdi, Phuntso.
1985 *Manual on Hill Roads in Bhutan* Paper Presented at SARC Seminar on Rural Roads, Kathmandu, June.

Wegmuller, P.
1972 *The Western Hills Road, Dhangarhi-Dandeldhura: Some Comparisons with the Feasibility Study for a Jiri Road.*

Wingett, W. J., Trueman B., and Limbu, B.
Pokhara-Lumle Road Feasibility Report Proposed Alignment Trace.

World Bank.
1975 Report No. P. 2117-NEP
Report & Recommendations of the President of IDA to the Executive Director on a Credit to the Kingdom of Nepal for a Second Highway Project, June 24.

Yadhav, Bindeswar.
1985 *Road Development and Rural Roads in Nepal.* Report to SARC Seminar on Rural Roads Kathmandu, June.

Zavadsky, V. B.
Results of Mission to Nepal to Study Problems Relating to Construction of Highway, Janakpur-Kathmandu.

Zinkle, W. D.
1979 *Die Arbeitsverhaltrisse im Lamosangu-Jiri Road Project* Nepal INDEL/Switzerland.

PAPERS PUBLISHED IN IRC JOURNALS:

Anderson, Capt. W. C.
1968 *A Method of Rapid Reconnaissance*, IRC Journal No. II, Paper 31, p. 398-416.

Bhirud, L. L.
Geometric Design of Hill Roads, IRC Journal XXX - 1, Paper 268, p. 283-298.

Chandra, Brig. Harish.
1977 *Problems of Engineers in the Himalayas*, IRC Journal XXXV, p. 363-386.

Chandrashekharan, E. C.
Construction of A Ghat Road from Brodinarykarnu to Bodimetta, IRC Journal XXX-1, Paper 256, p. 28-39.

Chaudhary, B.
1952 *Location of Roads in Hilly and Mountainous Country*, IRC Journal XVII-1, Paper 166, p. 41-57.

Cormack, F. E.
The Construction of Shillong-Jaintiapur Road, Khasi Hills Assam, IRC Journal, Volume Ii, Paper No. 3, p. 290-397.

Dutta, D. C.
Slip and Subsidence in a Hill Road, IRC Journal VI, Paper 139, p. 1-17.

Geological Survey of India.
1953 *Census of Landslips and Suggested Remedies*, IRC Journal XVII, p. 562-575.

Gupta, S. N. and De, P. L.
1956 *A Study on Road Figures*, IRC Journal No. XXV-4, p. 562-575.

Khaira, V. A.
Geology in the Design and Costruction of Hill Roads IRC Journal XXX-2, p. 369-386.

Mahapatra, M.
Drainage in Hill Roads, IRC Journal No. X-1 & 4 Paper 106.

Pal, S.C. and Das, R. C.
Construction of the Shillong Silchar Road, Assam, IRC Journal XVI-2, Paper 158 p. 151-204.

Srirangacharya, G.
Low Cost Roads in India and Use of Soil Science for Their Improvement, IRC Journal XIII-1, Paper 135, p. 59-146.

Woolwortus, Col. F.L.D.
Low Cost Roads for the East, IRC Journal XII-3, Paper 125, p. 283-327.

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Founding of ICIMOD

ICIMOD is the first International Centre in the field of mountain area development. It was founded out of widespread recognition of the alarming environmental degradation of mountain habitats, and consequent increasing impoverishment of mountain communities. A coordinated and systematic effort on an international scale was deemed essential to design and implement more effective development responses in each of the countries concerned.

The establishment of the Centre is based upon an agreement between His Majesty's Government of Nepal and the United Nations Educational, Scientific and Cultural Organization (UNESCO) signed in 1981. The Centre was inaugurated by the Prime Minister of Nepal in December 1983, and began its professional activities in September 1984.

The Centre, located in Kathmandu, the capital of the Kingdom of Nepal, enjoys the status of an autonomous international organisation.

Participating Countries of the Hindu Kush-Himalaya region

- Nepal
- China
- India
- Pakistan
- Bhutan
- Burma
- Bangladesh
- Afghanistan

Director: Dr. K.C. Rosser

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