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,

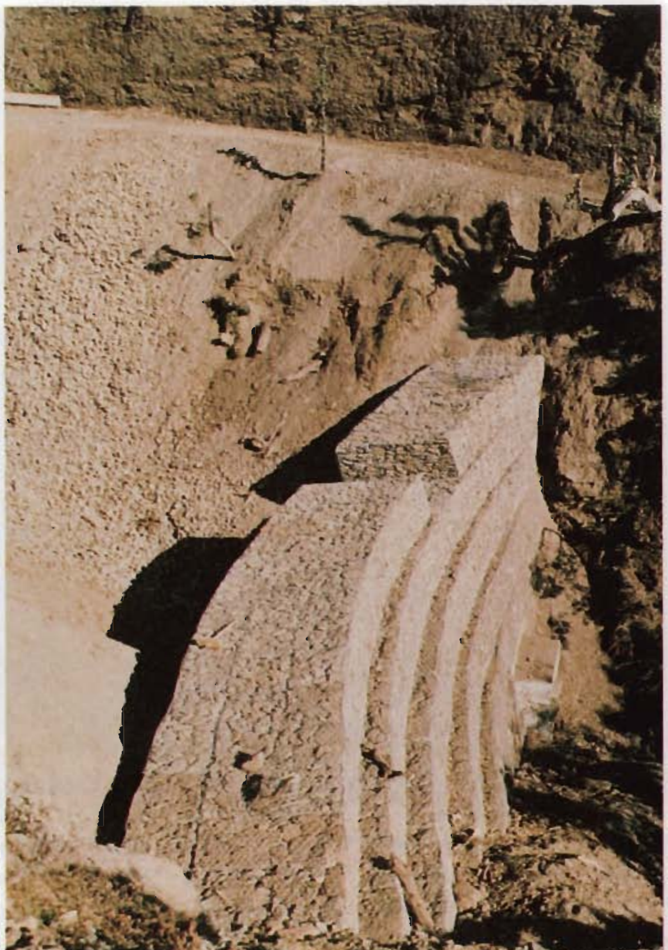

Plate 16: Vs gabion retaining wall under construction. The last layer is 3 m wide.

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

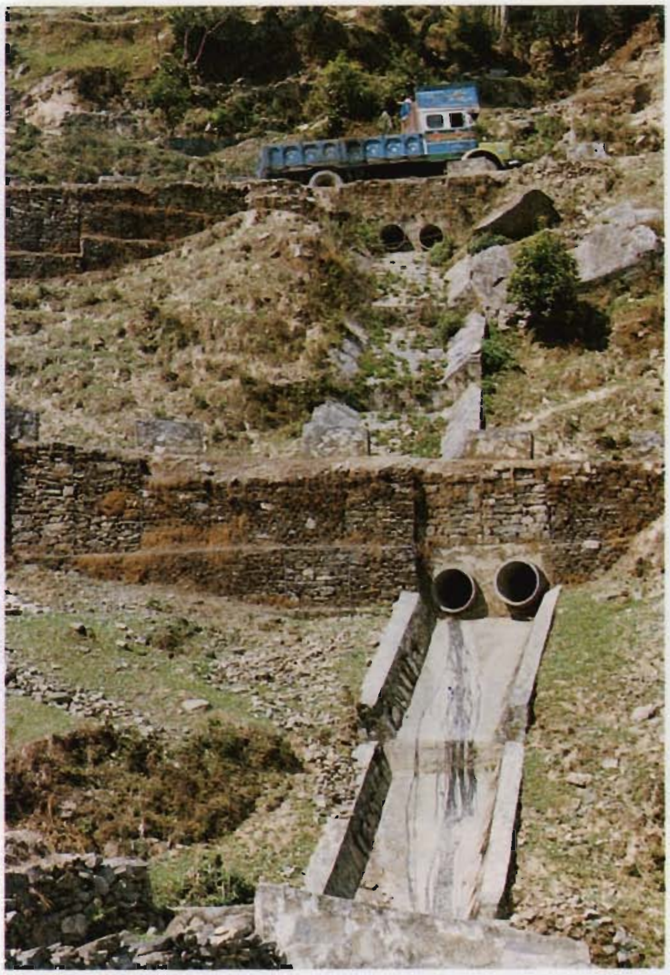

Plate 17: Two subsequent double pipe culverts 0.60 cm with controlled outlet over some distance.

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.

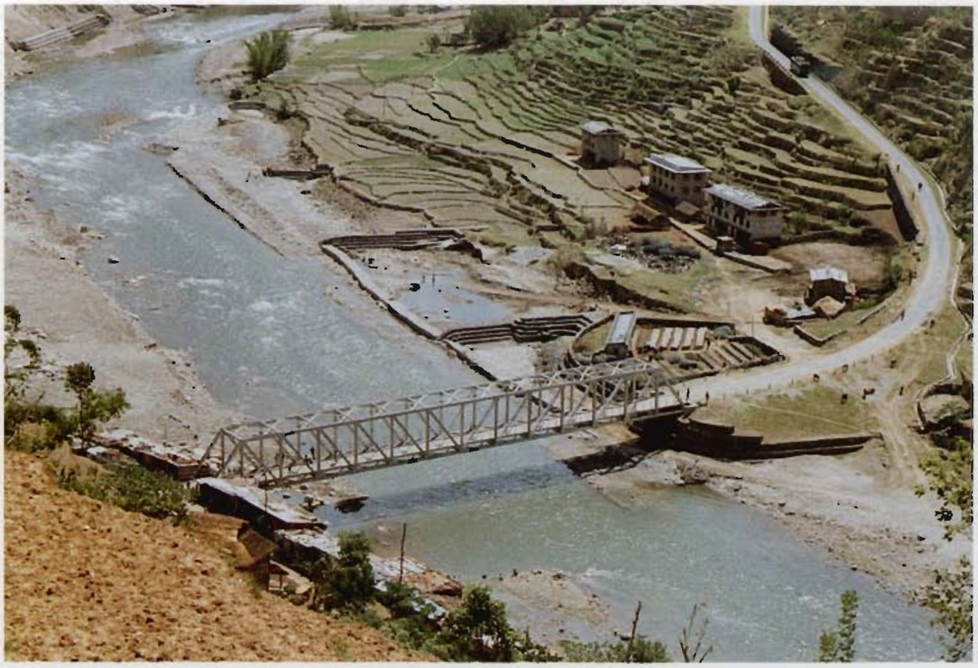

Plate 20: Sun Kosi Bridge. The erosion protection structure above the bridge consists of 4 spurs on the right embankment and 5 spurs on the left side, of which only the 2 highest ones are still visible (the other ones are already covered by river gravel and have therefore fulfilled their task)

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.

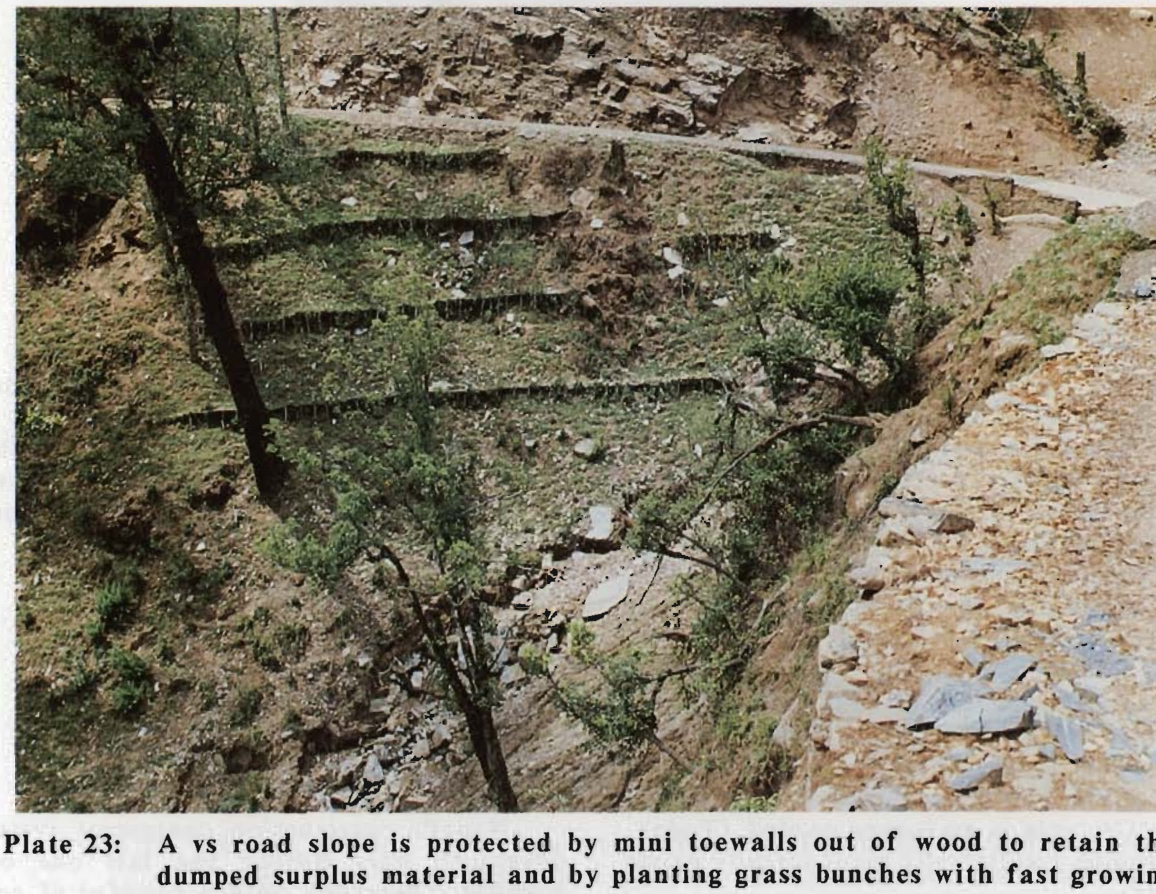

Plate 23: A vs road slope is protected by mini toewalls out of wood to retain the dumped surplus material and by planting grass bunches with fast growing and deep rooting properties).

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 subcontractors 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

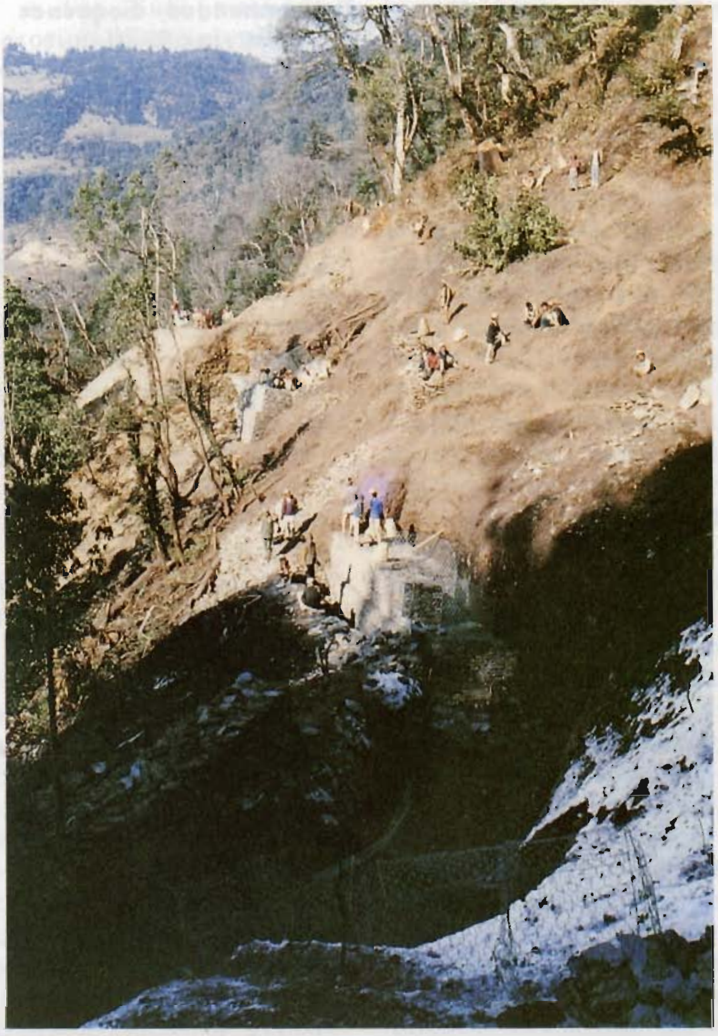

Plate 27: Erection of vs walls before the excavation of the road profile starts.

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:

- o 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),
- o Eventual last horizontal shifting of alignment for economisation of cost,
- o Removal of topsoil within the same stripe and deposition above the cleared area for re-use,
- o 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 washouts 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.