Chapter 6 Technical Aspects

6.1 Road Identification and Selection

6.1.1 Road Identification

The system of government in Lao PDR grants a wide degree of autonomy to districts and provinces in the formulation of their rural development programmes. Projects are identified at the local level and forwarded to Vientiane for approval and funding. However, projects are often identified at random, often based on requests from local residents or local political figures. No clear criteria for selecting rural infrastructure projects are available and there is little evidence of planning based on an overall assessment of the demand in the rural areas. In terms of road development, road projects are mostly identified in isolation and do not form part of an integrated strategy to improve living conditions in a selected area.

Also when looking at the road sector in isolation, there is a great demand to improve planning and maximising the effect of the limited funds available to maintain a rural road network. Although there are some recent improvements, there is still a common practice of giving priority to new construction rather than maintaining the existing road network.

An important component of the capacity building at provincial level will therefore be to establish effective management tools for the identification, selection and prioritisation of road construction and maintenance works in the provinces. This planning should not be limited to road network planning but also take into consideration the development programmes of other sectors operating in the rural areas, i.e. agriculture, education, health, etc.

The development of this capacity will involve both the DCTPCs as well as the DPCs and the rural development committees.

The on-going ILO Integrated Rural Accessibility Programme has gathered important experience relating to collecting information on rural infrastructure in the rural areas, and based on this data carry out integrated rural infrastructure planning.

The TPU, with technical assistance from the ILO, is presently applying a local level rural infrastructure planning system in three provinces, Oudomxay, Savannakhet and Luang Namtha. The system, Integrated Rural Accessibility Planning, is proving to be very successful as it has in other countries of the Region where it has been used. The process looks at the access needs of the rural population and prioritises both locations and interventions which directly relate to the needs of the people. Naturally, many of these interventions relate to improving people's mobility - roads, transport services and tracks. In addition, it also identifies the most appropriate siting of services such as schools, health clinics and markets.

One of the important aspects of the IRAP process is that it places the development of road infrastructure in the context of overall rural infrastructure planning, thus maximising the benefits of both.

The IRAP project will in the near future expand its activities to Xayabury, Sekong, Xiengkhuang provinces. It is proposed that future rural road development projects build on this important addition to local level planning. This would have several benefits:

- The provinces would follow the same planning procedures being promoted by the TPU today.

- It would ensure that rural road planning would be placed in the context of overall rural development planning in the provinces.

- It would maximise the potential benefits of the rural road programme.

- It could make use of the capacity that already exists in the TPU and some provinces for effective local level planning.

6.1.2 Road Selection

Once the technical feasibility of proposed road improvement works has been established, the selection and prioritisation of individual projects are subject to two basic criteria:

(i) economic justification and
(ii) social considerations.

(i) Criteria for Economic Justification

Various investment models are available to carry out the economic analysis. The benefits normally considered in an economic evaluation are:

- direct savings in the cost of operating vehicles,
- economies in road maintenance costs,
- time savings by travellers and freight,
- reductions in road accidents (although these often *increase* on improved roads), and
- wider effects on the economic development of the region.

Investment models are also available to estimate the total transport costs associated with different road surfaces including vehicle operating costs, maintenance costs and renewal costs under a variety of traffic, climatic and maintenance conditions.

Rural roads, however, represent the grass roots of the road network which feed traffic into the secondary and primary roads opening access to the rural areas. The rural roads have low traffic volumes and are generally constructed with gravel surfaces. For these roads the economic justification for the investment rests mainly on the expected impact on the rural and agricultural development. Both these outputs are time related and have a large element of uncertainty.

The extent to which the local economy adjacent to the proposed road will benefit from the investment is dependent on its economic potential such as unused land, irrigation facilities and labour, transportation facilities and costs. To forecast an increase in agricultural production, producer surplus and assessment of resultant producer benefits is a complex and difficult task.

This effect on the economy is extremely difficult to predict and virtually impossible to model, and any assessment made will have a high element of uncertainty, and relies on a series of external factors.

In terms of maintenance economics, there are, however, clear guidelines which can be followed. A basic rule for any road works programme is to protect previous investments and therefore to allocate available funds according to the following order:

(i) First, provide routine maintenance to the sections of the network which is in a good and maintainable condition. "Good" condition is regarded as when the road section requires a minimum of routine maintenance, which can be provided through a lengthman system.

(ii) Secondly, provide spot improvements and periodic maintenance to halt the deterioration of road sections in fair condition, thereby upgrading them to a maintainable condition.

(iii) Thirdly, rehabilitate existing roads which has fallen into total disrepair.

(iv) Once the three activities above have been secured, including regular maintenance for the newly upgraded road sections, one should be looking into new construction and expanding the road network. Once again, new projects should only be accepted when sufficient maintenance resources are available or can be secured when the construction of the new roads have been completed.

(ii) Social Criteria

The following are amongst the social criteria that may be used for ranking rural road rehabilitation projects:

- Present condition of the road. Communities without any access should be given high priority. The better the existing access, the lower the priority.

- The availability of access year - round. Communities without access only during some parts of the year should have higher priority.

- The area influenced by the road. The larger the area of influence, higher the priority. The correct determination of the area served is important but is difficult to identify. The limits of the area are generally provided by watersheds, rivers or the proximity of adjacent roads. In the situation of rural roads in Lao PDR, the area within walking distance of two hours from the proposed road can be taken.

- The inhabitants served. The greater the number of inhabitants to be served, the higher the priority.

- Present transportation costs per km. Road transport costs are related to the road condition. The higher the present costs, more these costs will decrease by road improvements.

- The area of cultivable land within the area of influence. A rural road programme should benefit as many farmers as possible. Roads leading to fewer farms and houses should be given lower priority.

- Increased area of cultivable land. By improving access, the inhabitants may be encouraged to cultivate more land within the area of influence of the road.

- Orientation of local produce to the market. The greater the volume of marketable produce, higher should be the priority for road improvement.

- The potential increase in marketable production. Increased production is related to road conditions, because improved access to markets will encourage the inhabitants to produce more goods to sell.

- The availability of social and economic services. Most of the social and economic services (medical, educational, and agricultural inputs) end where the trafficable road ends and go no further. Improved access can extend these services to isolated communities.

From the above, it is clear that a certain volume of data needs to be collected before a ranking can be established. Furthermore, it is also evident that some of the criteria are in conflict with each other (i.e. maintenance economics versus areas without road access). It is therefore important that the political leadership in the rural areas are fully involved in the final weighting of the criteria and final selection of projects to be included in the provincial road works programmes.

In this respect, the ILO IRAP project has collected some very useful experience, both in terms of an appropriate methodology for data collection as well as establishing road works priorities in the context of an overall rural infrastructure development plan.

6.2 Road Structures and Design

Traffic levels in Lao PDR are low. On the main roads, traffic volumes range between 15 and 336 vpd, though at most traffic count sites average daily traffic is below 150 vpd[1]. Information on traffic on provincial or rural roads is scarce since traffic surveys have so far only been carried out on the national roads. However, based on village surveys and evidence some five years ago, the National Transport Survey (NTS) estimated that a population of about 1000 households within 20 km of a passable road could generate a traffic volume of 3 vehicles per day. This could now be an underestimate as there is evidence of substantial increases in traffic volumes on the main roads since 1991 and the requirement for permits to travel outside the province has been removed. The study also estimated that, on the basis of transport cost savings alone, because of the high costs of alternative forms of transport, a rural road costing between US$ 5,000 and US$ 10,000 per km could be economically justified with a population of 300 to 400 households within an area of influence which could stretch up to 20 km from the road. The assessment did not take account of the potential for economic development or the benefits of better access to services.

The selection of design standards is related to road function, volume of traffic and terrain. The design process as such deals with the following main steps:

- Establish road function.
- Assess the design traffic and its characteristics.
- Assess other factors which should affect the design (terrain, type of sub-grade, sub-grade strength, availability and cost of construction materials, etc.).
- Select geometric design standards (road cross-section, design speed and speed related standards).
- Select appropriate pavement design (total pavement thickness, thickness and type of materials for each component layer).
- Assess the need for road structures (bridges, culverts, retaining walls, etc)
- Assess the availability of labour in the vicinity of the road work sites.
- Assess the availability of local contractors.

The selected design should be justified economically and the optimum choice varies with the construction and road user costs.

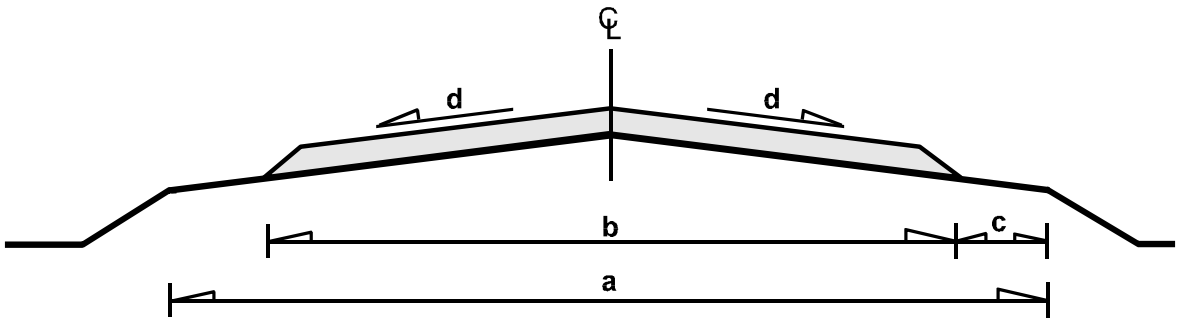
In Lao PDR as elsewhere, any suggested standards must be based on economic and technical considerations. The total rehabilitation needs are huge. Hence, functional standards are recommended. These can always be revised upwards as the traffic increases and more funds become available, in a stage construction process.

The capacity for planning, design, construction and supervision is also a major constraint today and will remain so in the foreseeable future, since the total resources are limited.

MCTPC has recently developed a design manual which has now been officially approved, however, on a provisional basis to be tested out before a final version is established. Unfortunately, this manual has been developed for the use of traditional equipment-intensive work methods without any serious consideration as relating to the use of labour-based methods and other locally available resources. It is therefore important that the use of labour-based technology is properly incorporated in the design standards before a final version of this manual is prepared.

[1] Estimates from the Transport Planning Unit, MCTPC

The MCTPC Design Manual contains guidelines on appropriate geometrical design of roads depending on the expected traffic loads of the roads divided into seven different classes. Of particular interest is the design guidelines prepared for class V, VI and VII roads which are summarised in Figure 6.1.



Parameter	Ref.	Class V			Class VI			Class VII			ILO	
Type of Terrain[1]		F	R	M	F	R	M	F	R	M	F	M
Average Daily Traffic (vpd)		100-300			50-100			< 50			< 50	
Design Speed (km/h)		60	40	20	60	40	20	40	30	20	30	
Formation Width (m)	a	7	7	6.5	6.5	6.5	6	6	6	5.5	5.5	5.5
Carriage-way Width (m)	b	5.5			3.5			3.5			5.5	
Shoulder Width (m)	c	0.75	0.75	0.5	1.5	1.5	1.25	1.25	1.25	1.0	0	0
Cross-fall (%)	d	3 - 4									8	
Max Gradient (%)		7	8	9	7	8	9	8	9	10	10	
Max Axle Load (tonnes)		9.1									5	

1 Flat, Rolling and Mountainous terrain

Figure 6.1 Standard Cross Sections

For comparison, this figure also provides the key dimensions for the roads built by the ILO labour-based road project in Oudomxay and Savannakhet.

From past discussions with the provinces regarding the selection of roads to be rehabilitated/constructed, it is evident that the traffic volumes will be in the range of 20 to 50 vehicles per day, maybe with a few exceptions with an average daily traffic of 50 to 100 vpd. Such traffic volumes would prescribe Class VI and VII design standards according to the MCTPC guidelines.

However, there are two important issues which should be considered when choosing the exact design of the rural roads:

(i) The cross-fall gradient of the camber should be increased from 3-4% to 8%. Experience from other rural road rehabilitation programmes clearly show that a cross-fall of 4% is insufficient. After completion and when traffic starts to wear the surface pavement, this will start at the centre of the carriageway and thereby reduce the cross-fall drainage and lead to an accelerated deterioration of the wearing course. By increasing the cross-fall gradient to 8% this effect can be delayed, reducing and delaying future maintenance requirements.

(ii) The MCTPC design guidelines propose relatively wide shoulders with an unprotected sub-base for low-volume roads. With the narrow carriage-width on the Class VI and VII roads, meeting traffic will be forced to utilise the shoulders. Without any protection of the shoulders, they will rapidly deteriorate, and if repairs are not carried out immediately, the damage may obstruct the cross-fall drainage. Furthermore, in silty soils it may prove difficult to protect the shoulders from erosion caused by cross-fall drainage. An effective way of solving this problem would be to expand the wearing course to also cover the shoulders, and

to provide turfing of the side slopes. This solution require higher initial investments during the rehabilitation/construction phase but significantly reduces future maintenance requirements.

As a result of these observations, it is proposed that the design standards as described in Figure 6.2 are utilised for rural roads.

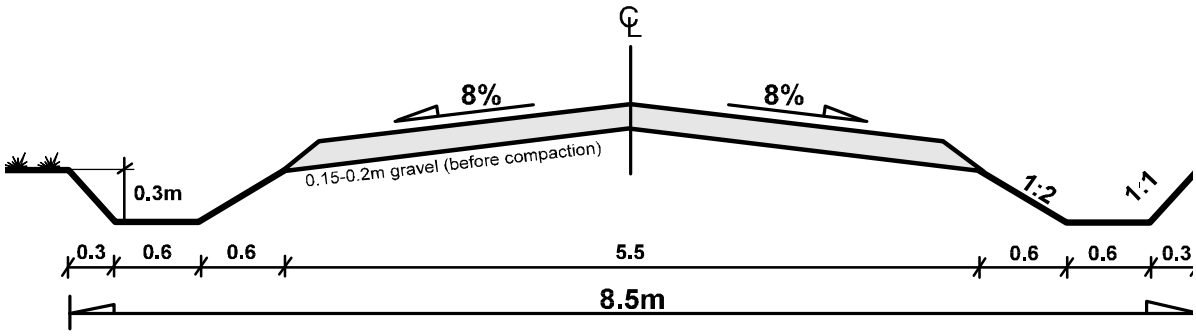


Figure 6.2a Standard Cross-Section

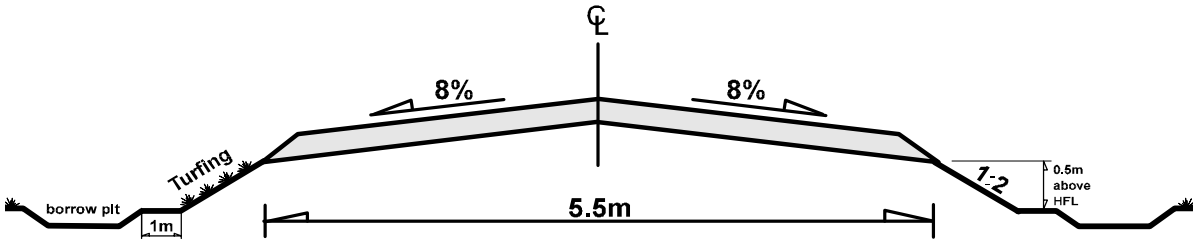


Figure 6.2b Cross-section in Flat and Flood Prone Terrain

Pavement Design

Gravel/laterite surfacing from good quality sources is considered fully adequate for the present volume of traffic and anticipated in the near future. Bituminous paving is not usually justified, till the traffic reaches levels of 150 vehicles per day.

Therefore, it is proposed that gravel is provided to a thickness of 10 to 15 cm after compaction. In exceptional cases with higher traffic volumes (100-150 vpd), it is recommended that the gravel layer is increased to 20 cm (after compaction).

Small Bridges and Structures

For small bridges and other drainage structures, there is a great potential for utilising local industries if the design standards take into consideration locally available skills and materials.

Lao PDR is still blessed with adequate supply of high quality timber which can be used for bridge construction and maintenance. Supply of materials and construction works of this type should be possible to award to local companies.

Culvert pipe production can be organised as a local industry which requires very little equipment and mainly relies on skilled labour. If the local industry receives sufficient advance notice on future requirements, the supply of pipes can be organised through local manufacturers.

Locally available stone should be used for abutments, piers, wing walls and retaining walls. The supply of stone can be awarded to petty contractors and farmers.

6.3 Construction Methods

Before venturing into the detailed work methods, it would be useful to once more repeat the definition of labour-based methods: *the construction technology which, while maintaining cost competitiveness and acceptable engineering quality standards, maximises opportunities for the employment of labour (skilled and unskilled) together with the support of light equipment and with the utilisation of locally available materials and resources.*

When considering the use of labour-based technology in road works projects, it is important to acknowledge its limitations. In some circumstances, traditional equipment-based work methods are more effective and may provide higher quality outputs, such as large excavation works, rock excavation and haulage of materials over long distances.

Although the technology may be unknown for many of the collaborators in the Lao rural road sector, it has been successfully tested and adapted to the specific conditions in Lao PDR through the ILO labour-based road project in Oudomxay and Savannakhet during the last two years. It is proposed that a future expansion of this project base its work methods on the experience made in these two provinces.

The description below, provides a brief summary of the work methods.

6.3.1 Surveying and Setting Out

Appropriate surveying and setting methods can be easily introduced by using the "Profile Board Method". This method does not require any sophisticated surveying equipment but relies on simple equipment such as ranging rods, profile boards, measuring tapes and line levels which are easy and inexpensive to purchase. Furthermore, this method does not require well developed topographical maps. It is easy to teach, and when properly applied, the road alignment can be established in a manner avoiding heavy earthworks and rather establishing the road line well integrated into the natural topography of the terrain. Finally, when used by site personnel who fully master and use the technique properly, it will provide the accuracy and quality required.

By applying this method, it is also possible to take due consideration of existing farming and other economic activities in the areas through which the road will be passing.

6.3.2 Clearing

The clearing of the road reserve is a work activity which is easily organised by unskilled labour, since this is an operation which is common among farmers in the rural areas. Clearing mainly consists of removing vegetation and topsoil. In rocky areas, it is important to find an alignment which reduces the rock excavation and removal to a minimum. If rock excavation cannot be avoided, it is recommended that regular drilling and blasting methods are applied.

6.3.3 Earthworks

Earthworks can be reduced to the following types of operations depending on the prevalent terrain conditions:

(i) Cut to Fill

In hilly and mountainous terrain where the road pass through sloping terrain, earthworks mainly consist of cut to fill excavations. By carefully designing the road alignment, movement of earth along the road line should be avoided/ minimised. If longitudal earth movements are avoided, it is normally possible to entirely rely on the use of manual labour.

(ii) Embankment Construction

In the lower lying and flat areas, the roads often pass through rice farming lands which are prone to floods in the rainy season. When constructing embankments through such areas, it is important to first determine the High Flood Level (HFL). The embankment should be constructed to a level 0.5m above the HFL. Normally, it would be possible to borrow soils in close proximity along the road alignment.

The shoulders should have a minimum slope of 1:2, and to avoid erosion, protected by grass turfing and tree planting. Figure 6.3 describes the basic design of an embankment for rural roads.

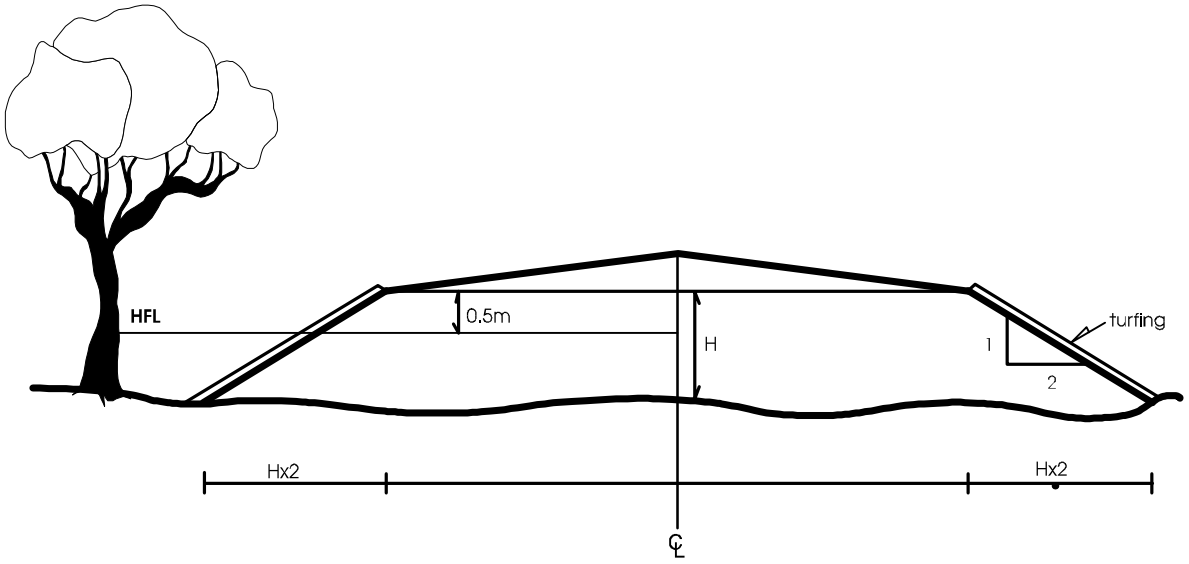


Figure 6.3 Embankment Construction

Soil excavation, transport and filling can be organised through the use of manual labour.

When building embankments, it is important that the cross road drainage is designed in a fashion so that it does not conflict with the irrigation system in the surrounding farming areas.

(iii) Drainage

Side drains are easily excavated by manual labour. To avoid soil erosion and silting of drainage structures, scour checks should be installed at regular intervals.

(iv) Camber Formation

The road camber is normally produced using excavated soils from the side drains. For embankments, the required materials need to be excavated from a borrow pit near the road.

Setting out of side drains, mitre drains and camber can be carried out using the Profile Board Method.

6.3.4 Compaction and Watering

It is extremely important that all fill sections are properly compacted, so that there are no more settlements when the camber and gravel surface is constructed. This implies that the fill sections must

be compacted in layers not thicker than 15-20 cm. For compaction, it is recommended that vibrating 0.6 to 1.0 tonne pedestrian rollers are used.

Optimum moisture content must be ensured during compaction. If necessary, water needs to be added to dry soils, or soils need to be dried during excessively wet periods.

6.3.5 Gravelling

Surface materials will most probably need to be transported using traditional equipment (tipper trucks and loader/excavator) and compacted using vibrating rollers. This operation can be sub-contracted to existing local contractors.

Levelling works, if properly organised and with proper supervision, can be carried out by manual labour.

6.3.6 Bridges and Culverts

Bridge and culvert works should follow established work methods which have always relied on a high degree of manual labour. However, with rural roads, where very low traffic volumes are expected, it is important to explore the use of low-cost structures such as drifts and inverted culverts. Furthermore, the feasibility of using more local building materials such as timber and stone should be explored in future programmes. Manufacturing, supply and installation of culverts, vented fords and drifts could be awarded to local contractors.

6.3.7 Task Work

In order to achieve good production rates, it is recommended that incentive schemes are offered to the workers. The most common solution is to introduce task work on the various site work activities. It is the responsibility of the site supervisor that the workers receive their tasks in the morning immediately when they arrive, and that the amount of work is fair and just. The size of the task must therefore be carefully monitored to ensure that the amount of work given to each worker is neither too little, nor too much. Table 6.1 shows some average task rates, however, they should only be used in an initial phase, before more appropriate quantities have been determined through site trials. Once agreed, the workers should stay on site until their task in completed.

Clearing and Grubbing	50-150 m•/wd	Camber Formation	75 m•/wd
Levelling	1.5 - 3.0 m•/wd	Turfing	10-20 m•/wd
Earth Excavation, 20m transport and hand compaction	1.5 - 2.5 m•/wd	Gravelling (spreading and levelling)	5-10 m/wd
Drain Excavation	1.5 - 3.0 m•/wd		

Table 6.1 Task Rates

6.4 Road Maintenance

The work of the ILO and others working over recent years on the problem of road maintenance has demonstrated that it is feasible to involve the local population more extensively in road maintenance works, provided that suitable incentive schemes are introduced and an adequate supervisory and management structure is established. The development and utilisation of small local contractors for road maintenance works is a promising avenue which needs to be explored to the maximum extent possible.

The socio-economic environment and the state of development of a particular area play a determining role. In recent years, however, a great deal has been learnt on the establishment of alternative road maintenance systems. One could categorise those as follows:

- Direct labour employed as permanent or semi-permanent staff, supported by equipment (classical approach).
- Individual or collective maintenance responsibility for a road section.
- Agreements between communities and government.
- Petty contracts for selected road maintenance activities.
- Use of the private sector.

Of course, it is possible to combine or modify the above approaches in many ways. It is evident, however, that the classical approach does not currently operate in a satisfactory manner. Moreover, the overall working environment in which road maintenance is carried out continues to be unfavourable.

In applying any of the alternative options the key element to take into account is the motivation of the workers and their supervisors. Incentives at all levels must be incorporated as part of the system in order to make it sustainable in the long term. As concerns the workers at village level such incentives may not necessarily have to be material. If there is a significant local interest in the road (or road section), some assistance in the form of tools, construction materials and supervision could be a sufficient incentive to mobilise adequate numbers of workers.

In these cases, planning and programming assistance may be sufficient to mobilise and direct village labour at specific times throughout the year to bring the road back into a trafficable state. This type of maintenance would therefore be provided not as a continuous low level routine maintenance input, but rather as a scheduled and well-directed community input involving a significant number of workers say two to three times per year.

The purpose of this type of intervention would be to put the road back into trafficable state when it would be most urgently required. The timing of the interventions should be discussed and agreed upon between the villagers and the supervising technical ministry and would depend on technical, economic and social considerations. Naturally, this type of maintenance intervention would primarily apply to access roads with very low traffic levels and where communities are prepared to provide (subsidised) collective inputs to safeguard their level of access to the main road network.

In the majority of cases, however, further inputs in the form of money or food will be necessary to establish a continuous and sustainable maintenance system. The level of such inputs could, however, be kept minimal if agreements with communities and/or village organisations are negotiated. In this way, the beneficiaries of the roads are directly participating in and contributing to its maintenance. Regular and sustained inputs can also be commercially negotiated with individuals or lengthmen (who may be grouped together) or through petty contracts.

Alternatively, systems of financial contributions or local taxes could be negotiated with the local beneficiaries.

Using petty contracts for the execution of different routine maintenance activities has been shown to have the following advantages:

- Flexibility of contractors (ability to introduce incentive schemes, control of labour force).
- Less bureaucratic procedures.
- Government released of direct management responsibilities.
- Contractual commitment of maintenance funds (difficult to divert funds to other purposes).
- Political support for well defined activity.
- Development of skilled local contractors.

On the other hand, the private sector has (as yet) little relevant experience in carrying out routine maintenance contracts. However, small-scale village based petty contractors without previous experience quickly assimilate the necessary skills to organise a number of workers. The crucial issue is to adapt the working environment so that the contractors can perform without constraints and without losing confidence in the employer.

One can argue that in the long term there will not be sufficient funds available to pay the full cost of rural road maintenance. In such a situation, much more thought has to be given to involving the communities in the repair and maintenance of the rural roads.

This is an issue which is often susceptible to simplistic solutions. An argument often heard is that rural roads are built specifically for the benefit of the people and they should therefore shoulder the responsibility for maintaining the road.

One has to remember that roads are built to carry vehicles. Many communities recognise the benefits that will come to the community from the better access to markets, easier access to government services and better connection to the outside. Nevertheless, they do not necessarily recognise the individual benefit that will come to them. After all most of them do not own a vehicle. In Lao PDR, many are subsistence farmers and have no real need of markets. Indeed they may feel that as individuals they cannot see the benefit that will accrue to them. At best, they may be prepared to maintain the road where it runs through the village but, experience suggests that, they will be unwilling to maintain more than that.

This is not to suggest that it is not possible to obtain community support for rural road maintenance. However, it is necessary to put a lot of effort into:

(i) ensuring that the community fully understands the benefits that will come to them from maintaining the road and

(ii) providing some form of incentive to the communities.

The lessons to be learned from attempts to involve the local population in the maintenance of rural roads are the following:

(i) The communities must be involved in the process from the planning stage. Indeed, the road to be built has to be seen by them to be something that they need and not imposed on them from outside.

(ii) In this respect, it clearly helps if the roads are built using local labour as the community is then involved and benefitting from its construction.

(iii) Some form of incentive has to be provided. This of course is best if it is cash. However, there are other forms of incentives:

  (a) If the road is to be used mainly for exporting produce some sort of levy can be made on the those benefitting from the sale of the produce.

  (b) If the road is of obvious benefit to the communities then some form of maintenance fund can be set up which can be furbished from a small contribution from the communities, if possible augmented by the local authorities. Such a fund can be used to pay the maintenance workers or to pay local contractors. The fund could also be established by a small amount taken from the salaries of the workers involved in the construction.

(c) If the road specifically results in the possibility to market crops, a small levy could be introduced on those from which funds could be allocated to maintenance.

(d) The local authority could provide the basic tools such as hoes and wheelbarrows to the maintenance workers. Such tools can be used by the workers for their own activities.

(e) Food aid can be used either directly or converted into cash as the means to pay for road maintenance.

For the foreseeable future, programmes of rural roads will be funded by foreign assistance. It would be a mistake, however, to use these projects to pay for the maintenance of the roads constructed. Certainly donors should be encouraged to set funds aside to develop sustainable systems. However, it has to be accepted that merely putting money into rural road maintenance is not a sustainable solution. Funds that are available in these projects should be used to test out different forms of maintenance as illustrated above. In this way, it would be possible to arrive at solutions which the Lao PDR Government would be able to sustain.

6.4.1 Current Situation

There is practically no preventive road maintenance on the rural roads in Lao PDR, nor is there any proper maintenance set up in the provincial departments of MCTPC in the provinces. The main reason for this situation is the limited funds available for any type of maintenance activities. As a result, the roads keep deteriorating and the repair needs get more and more desperate. Even roads rehabilitated in the recent past have again deteriorated for want of regular maintenance.

Some development agencies have been involved in maintenance of roads constructed or rehabilitated by these agencies themselves for some time. During the last two years, ILO has been maintaining the roads constructed and rehabilitated by it. Presently, ILO is maintaining 30 km of roads in Oudomxay and 20 km in Savannakhet by the lengthman system and some sections using village-based contracts. In addition, Oudomxay Province has recently established a routine maintenance by the "length-man" system on its national road network.

6.4.2 Routine Maintenance

Routine Maintenance Tasks

- o Repair, fill and compact pot holes and ruts;
- o Erosion control of shoulders and slopes
- o Clear side and mitre drains to allow free passage of water;
- o Clear culverts and other water ways;
- o Cut grass and bushes;
- o Maintain road signs in place;
- o Perform minor repairs to culverts and retaining structures;
- o Repair and replace scour checks.

Routine maintenance of low traffic rural roads is a widely dispersed activity, requiring small resource inputs over a large number of widely separated points. This activity is best suited for manual labour. The amount of work needed to keep a length of road in good condition depends on several factors, such as type of road surface, traffic volume (number, type and size of vehicles), the severity of climatic conditions, especially rain fall, type of soil; the susceptibility of the terrain and road gradients to erosion, and the presence of bush and vegetation.

Under average conditions, one full time worker should be able to cover the routine maintenance works each year of 1-2 km of single lane gravel road, with traffic of about 25 vehicles per day (ref. Table 6.2). This activity can be most economically performed by persons living along the roads and engaged for road maintenance. Local workers are also under social pressure from their neighbours to do the job well. Former road construction workers are ideal maintenance workers, because they already have some training and experience in the work involved.

6.4.3 Recurrent and Periodic Maintenance

Periodic road maintenance works involve activities such as reshaping of the road surface, re-gravelling and repair or reconstruction of damaged drainage structures. Such works could be organised the same way as rehabilitation and new construction works under a contract system, works carried out by small-scale private contractors (with a limited amount of equipment), and supervised and managed by staff of the DCTPCs.

PRODUCTIVITY GUIDELINES FOR ROUTINE MAINTENANCE							
ACTIVITY		Unit	TASK DIFFICULTY 1	2	3	4	NOTES
Clean Culverts + Inlets		As shown	4 Culverts per day	1 Culvert per day	2 Days per Culvert	4 Days per Culvert	Difficulty = Silt depth in culvert 1. Up to • 2. • to • 3. • to • 4. Over • Tasks for 600 dia.culverts with 7 rings
Clean Culvert Outfalls		m/day	55	40	25		Difficulty = Silt depth 1. Up to 10cm 2. 10 to 20cm 3. Over 20cm
Repair Culvert Headwalls		No/day	7	4			Difficulty = Type of repair 1. Minor repairs 2. Major repairs
Clean Mitre Drains		m/day	60	45	30		Difficulty = Silt depth 1. Up to 20cm 2. 10 to 15cm 3. Over 15cm
Clean Side Drains		m/day	wet areas 65 dry soft soil 55 dry hard soil 30	45 40 23	30 30 18		Difficulty = Silt depth 1. Up to 20cm 2. 10 to 15cm 3. Over 15cm
Repair Scour Checks		No/day	5	7			Difficulty = Type of scour check 1. Wood 2. Stone
Repair Side Drain Erosion		m/day	wet areas 100 dry areas 100	80 50	60 23		Difficulty = Depth of Erosion 1. Up to 15cm 2. 15 to 30cm 3. Over 30cm
Repair Shoulder Erosion		m/day	100	80	65		Difficulty = Depth of Erosion 1. Up to 10cm 2. 10 to 15cm 3. Over 15cm
Grass Planting		m/day	100	80	65		Difficulty = Planting width 1. Up to 0.5m 2. 0.5 to 1.0m 3. Over 1.0m
Fill Potholes in Carriageway		wheel-brws/ day	25	18	13	8	Difficulty = Hauling Distance 1. No haul 2. Up to 100m 3. 100m to 200m 4. Over 200m
Fill Ruts in Carriageway		m/day	wet areas 70 dry areas 50	50 30	35 15	15 7	Difficulty = Hauling Distance 1. No haul 2. Up to 100m 3. 100m to 200m 4. Over 200m
Grub Edge of Carriageway		m/day	wet areas 270 dry areas 190	200 120	130 70		Difficulty = Width of grubbing 1. Up to 0.5m 2. 0.5 to 1.0m 3. Over 1.0m
Reshape Carriageway		m/day	70	50			Difficulty = Type of reshaping 1. Light (Up to 75mm) 2. Heavy (over 75mm)
Cut Grass	Light	m/day	wet areas 425 dry areas 310	260 230	190 170		Difficulty = Width of grass cutting 1. Up to 1.0m 2. 1.0 to 2.0m 3. Over 2.0m
	Dense	m/day	310	240	175		
Clear Bush	Light	m/day	425	260	190		Difficulty = Width of bush 1. Up to 1.0m 2. 1.0 to 2.0m 3. Over 2.0m
	Dense	m/day	275	225	175		

* All tasks except reshaping are measured along one side of the road only.

Source: Minor Roads Programme, Kenya

Table 6.2 Production Rates for Routine Maintenance

6.5 Tools and Equipment

6.5.1 General

By definition, labour-based road construction and maintenance methods consist of an appropriate combination of utilising labour complemented with a limited use of equipment. Equipment for labour-based road works is mainly utilized for operations such as haulage of materials and water, compaction, grading and rock breaking. Well-designed and maintained tools and equipment are important as they determine the productivity as well as the quality of the works carried out. It is therefore important that the tools and equipment used for labour-based construction and maintenance activities are properly designed to stand heavy wear and tear and the normal abuse of a road work site.

The most common scenario is that 20% - 30% of total construction costs are attributed to equipment use. However, 90% of all headaches of project managers are related to the use of equipment. The workers turn up and perform every day, but the equipment breaks down. Malfunctioning equipment is very often the most common item which jeopardizes the progress of a road project.

The optimal choice of tools and equipment also varies from place to place, depending on the site conditions, type of works carried out, type of soils, local skills, etc.

Site supervisory staff are trained in the proper use and maintenance of tools and equipment. Since the labour is temporarily employed, they are not provided with any formal training in the use of tools and equipment. However, the supervisors are responsible for instructing the workers and ensuring that tools are properly used and maintained.

6.5.2 Tools and Employment for Construction Works

The equipment used on site needs to match the number of workers, thereby obtaining an balance between machine and labour operations. Experience has shown that with a labour force of 150-200 workers, the following equipment configuration is appropriate:

2 pedestrian rollers (950 kg)	26,000
1 Etean truck with water bowser	16,000
1 pick-up truck	16,000
1 motorcycle	1,500
2 bicycles	500
1 set of hand tools	4,000
Total	US$ 64,000

This assumes that provision of gravel is done by traditional equipment-based contractors with tipper-trucks and excavators.

The below table indicates the required hand tools for a project site employing 100 workers or 200 workers.

Item	200 workers	100 workers
Profile Board	100	70
Ranging Rod	100	70
Hoe	150	70
Hoe Handle	150	50
Shovel	75	50
Spade	30	20
Pickaxe	75	25
Pickaxe Handle	75	25
Crowbar	10	5
Bush Knife	10	5
Axe	15	5
Bowsaw	7	4
Grass Slasher	15	10
Heavy Duty Rake	40	30
Hand Rammer	25	20
Wheelbarrow	60	40
Sledge Hammer	3	3
Bucket	10	8
Watering Can	10	8
Fuel pump	1	1
30m Measuring Tape	3	3
3m Measuring Tape	3	3
Line Level	3	3
Nylon String	300 m	300 m

6.5.3 Tools for Maintenance Works

Periodic Maintenance

The main activities defined as periodic maintenance consists of major repairs on drainage systems, rehabilitation of road camber and regravelling. As can be seen, these work activities are quite similar to rehabilitation and new construction works, so, depending on the magnitude of the road deterioration, periodic maintenance works would require the same type of tools as described above.

Routine Maintenance

Required tools and equipment for routine maintenance consist of (i) tools for the lengthman and (ii) inspection transport for the road authorities.

Tools for the lengthman consist of the following items:

o hoe	o bush knife	o pickaxe
o sharpening file	o shovel	o hand rammer
o spade	o wheelbarrow	o spreader

A major item in a routine maintenance setup is the regular inspection and supervision of the lengthmen as well as the timely payment of the works. To carry out these activities successfully the road authorities must possess proper means to travel along the roads and meet with the lengthmen and/or lengthman contractors. Depending on the length of travel, supervision personnel needs to be equipped with bicycles, motorcycles or inspection cars.

6.5.4 Preventive Mechanical Maintenance

Regular mechanical maintenance of the equipment avoids break downs and ensures a long equipment life time and finally avoids disruptions in site works. The supervisors and operators must therefore be

trained in the proper operation of equipment thereby ensuring that preventive maintenance it is carried out at regular intervals. Operator manuals for each piece of equipment should be made available in a language which the site personnel understands, which specifies when and where lubrication and adjustments are required.

When labourers have to work with poorly maintained tools, their output is low. Therefore, effort spent on proper maintenance is amply repaid. The cost of employing a carpenter to make and fix tool handles or employing a blacksmith to sharpen handtools may be repaid many times over by the increased output resulting from better tool condition.

6.6 Labour Recruitment and Employment

6.6.1 Incentive Schemes

The workforce employed to execute labour-based road works are locally recruited within the vicinity of the road sites on a daily basis and are paid only for the days they have worked. They are normally not entitled any social benefits such as paid leave, pensions, sick leave, etc. They can be laid off when their services are no longer required. When the road construction and maintenance activities are moved to a new area, new workers are recruited from this area.

In order to ensure the required level of effectiveness on labour-based projects, serious attention must be given to the motivation of the labour force. This is ensured by various measures such as appropriate wages, proper supervision, secure working conditions, timely payment of wages and the use of incentive schemes.

Payment of works can be organised in various forms, depending on the nature of work and type of funding:

Daily Paid Work: Daily paid workers are paid a fixed sum for each day in return for a fixed number of working hours disregarding achieved work outputs. This system is often used when starting up a new project before an incentive scheme has been established. It is also used as the basis payment when productivities are low and the limits for the receipt of bonuses are not reached.

Task Work: Task bonuses are the most commonly used incentive scheme on labour-based projects. Task work implies that the labourer is given a clearly defined amount work to be completed in one day whereafter he is free to discharge.

Piece Work: On piece work each individual worker is paid per unit of output. The "pieces" are normally equivalent of between one to four times the output expected on daily paid work.

Payment in Kind: In areas where food supply is limited or where the local currency is highly inflated, payment in kind may act as an effective incentive. However, there are certain international standards which should be observed when paying with food for work.

6.6.2 Recruitment and Employment Conditions

Labour-based public works programmes require large numbers of unskilled and semi-skilled labour in a limited period of time. It is important that clear guidelines and procedures are available for the recruitment and employment conditions for casual labour recruited both by public and private sector institutions, including issues such as renumeration, incentive schemes and safety and health.

When expanding into large-scale use of labour-based methods, experience shows that particular attention has to be paid to the procedures for recruiting and paying the casual workforce and their working conditions. Casual workers are rarely aware of their rights under national labour laws and they are vulnerable to exploitation. In most cases, there will be more job seekers than required, and

accusations of corruption and favouritism should be avoided. It is important that the selection process is transparent and is felt to be fair. Apart from human and workers' rights, there are also economic arguments for fair treatment of the workers. Workers who are treated fairly are likely to develop a sense of loyalty with the employer, their motivation and productivity are likely to rise.

The risk of worker exploitation may be higher when private contractors are involved in the execution of the road works. It is therefore essential that labour issues are properly dealt with in contractor training programmes and that the contracts include clauses on relevant labour standards, and that these regulations are monitored by the client.

Liaison with the Ministry of Labour and Social Welfare should be sought during the planning and execution of a labour-based programme, not only for the purpose of controlling the working conditions but also to emphasize its advisory role.

6.6.3 Gender Considerations

Rural women make up 30 - 40 percent of the workforce employed by the current ILO labour-based project, demonstrating that this kind of work is both culturally acceptable and a potential source of income for women and their families.

When the road works are carried out using private contractors, it is important that the representation of women participation in the road works does not diminish. This issue needs to be carefully monitored, and if necessary, proactive measures need to taken, possibly by introducing quotas included in the special clauses of the road works contracts.

Female participation in the routine maintenance works is easier to control through the actual selection of petty contractors. Here again, the above representation should act as a minimum goal, however, not being regarded as a ceiling.

Finally, women should also be provided equal opportunities, in terms of recruitment for management positions, training and career advancement.

6.7 Environmental Aspects

Most roads needing rehabilitation follow existing tracks and therefore do not cause interference in the economic activities in the rural areas through which they pass. However, it should be acknowledged that the roads will be passing through areas where the farms are small and any encroachment on existing farm lands may have dire consequences for the local farmers. When using labour-based methods, supported by light equipment it is possible to constrict construction works to within the limits of the road width.

A major consideration in roads development is the requirements of existing irrigation systems and associated eco-systems, since it is of prime importance to retain water rather than, as road engineers may prefer, to allow free drainage regimes.

Road works operations, and in particular when using labour-based methods, can be organised so it is locally beneficial in terms of the scale of soil excavation activities. To form embankments, soil is excavated locally at regular intervals in the form of shallow borrow pits. After construction, these naturally fill with water and can become local fishponds. The siting of these pits can be agreed with local communities beforehand in order to gain the best future advantage for them. Laterite excavation is limited to a number of gravel pits where some environmental damage initially results. Borrow-pits can be well shaped and landscaped after excavation operations but many are widely and continuously used and any rehabilitation of the pits would be done at a later date. Eventually, natural vegetation will be very quick to reclaim these areas once they have been worked out.

On embankments, it is recommended that turfing is carried out and that trees are planted on the side slopes for soil protection purposes. The trees can be maintained during their growth period by the routine road maintenance lengthmen, and will improve the overall environmental conditions in the area.

Clearing of landslides comprise a major activity of road maintenance in the hilly and mountainous regions. The cause of the landslides is mainly due to side-cuts excavated to make place for the road width. Local farming activities adjacent to the road (in particular slash and burn activities) often accelerate this soil erosion process. This is a serious maintenance issue which needs to be considered already at the planning and design stage. In order to reduce future maintenance demands, road alignments should be designed in a fashion where side-cuts are reduced to a minimum. When side-cuts cannot be avoided, soil stabilisation measures such as retaining walls, tree planting, etc. must be implemented. These measures will involve increased initial costs during the construction period, but may significantly reduce future maintenance requirements.