WORLD EMPLOYMENT PROGRAMME

THE APPLICATION OF APPROPRIATE TECHNOLOGY IN ROAD CONSTRUCTION AND MAINTENANCE:

A Learning Methodology

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PREFACE

Over the past eight years the Technology and Employment Branch of the ILO has conducted a comprehensive programme on appropriate construction technology. The major thrust of this programme has been towards road construction and maintenance.

The results of the initial research work[1] showed conclusively that labour-based techniques were technically and economically viable for a wide range of road construction and maintenance activities.

The demonstration in the field that the research results were tenable proved to be a much more complex operation. The successful application of labour-based techniques was found to depend much more on organisation, management, administration and attitude than on technical and economic factors. A major breakthrough occurred with the launching, first on a pilot stage and then as a full-scale programme, of the Rural Access Roads Programme in Kenya[2] The development of this programme which has, to date, constructed some 4,000 km of rural roads using labour-based techniques at an average cost of $6,000 per kilometre, has shown how the various organisational and administrative problems can be solved.

Building upon the experience of the RARP, and other projects in the Philippines, Guatemala and Mexico, the ILO programme developed a range of inter-related activities designed to assist governments in the effective application of labour-based techniques. These activities can be categorised as research, the production of basic documentation (see Appendix 1), pilot projects, advisory services, full-scale technical co-operation projects and a series of seminars and workshops. It is in relation to the latter that this paper has been prepared.

In May 1977 the ILO, with the financial assistance of the Swedish International Development Agency (SIDA) and the Asian Development Bank, presented an Asian and Pacific regional seminar on the application of appropriate technology in road construction and maintenance in Manila. A number of national workshops followed this regional seminar in Sri Lanka, Indonesia, Burma, Afghanistan and Pakistan.

In March 1980, an African regional seminar was held in Addis Ababa and this has led to the planning of a series of national workshops in Africa. A workshop has already taken place in Tanzania and others are planned for Swaziland, Malawi and several other countries. These activities in Africa are financed by the Danish International Development Agency (DANIDA).

In the presentation of these seminars and workshops a particular methodology has been developed which seeks to engage the participants in a series of tasks, case

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1 See, for example, M. Allal and G.A. Edmonds in collabora- tion with 1.5. Bhala: Manual on the planning of labour- intensive road construction, ILO, Geneva l977; and D. Lal et al.; Men or machines: a Philippines case study of labour- capital substitution in road construction, ILO, Geneva, 1978.

2 See J.J. de Veen: The Rural Access Roads Programme: Appropriate technology in Kenya, ILO, Geneva, 1980.

studies and discussions which in total allow the participants to develop their own ideas and to arrive at their own conclusions regarding the appropriateness of the technology and the most effective means of applying it in their own particular circumstances.

This paper describes the content and methodology that has been developed for the seminars and workshops and in particular the one held in Arusha, Tanzania, in November 1980. Whilst both content and methodology are being developed further, we feel that even at this stage the material can be usefully applied in similar workshops and training sessions in other developing countries. Moreover, the various case studies and exercises will provide useful background and reference material to those involved in road construction and maintenance in developing countries.

We wish to acknowledge the useful suggestions and ideas that we have received from our colleagues in the Management Development Branch of the ILO.

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1. PATIONALE AND METHODOLOGY

The methodology described here attempts to provide a basis for effective decision making in relation to labour-based road construction projects. It has been used in the ILO's series of seminars and workshops on appropriate road construction technology.

The workshops provide training on:

(i) how to make, in different situations, a rational and justified choice between the use of either equipment- or labour-based techniques in road construction and maintenance;

(ii) how to plan, programme, execute and monitor labour- based road construction and maintenance projects.

The first part focuses on the identification of advantages and disadvantages of the use of labour and equipment. It also provides the participants with the means to more realistically estimate the costs of each type of technology in different circumstances.

The latter part concentrates on the specific problems which will be encountered when labour-based programmes are set up and executed. The main subjects of discussion are: planning, site organisation, productivity, training, tools and, equipment and maintenance.

In general, the following procedure *is* adopted when discussing each issue:

Step 1 - Identification of the problem.

Step 2 - Presentation related to the subject by one of the course leaders.

Step 3 - Formulation of a problem statement and group work on case studies/exercises/study tasks with a bearing on the particular problem.

Step 4 - Output of group work and subsequent evaluation of this output in plenary session. The groups are thus in a position to supplement. and criticise each other's work.

Step 5 - Formulation of integrated action proposals agreed upon by all participants.

Most of these steps are carried out by the participants themselves with only minimum guidance by the course leaders. Furthermore, to maximise the involvement of all individuals, a number of study tasks have been prepared. The participants work individually on such tasks in the evening so that the following morning they are familiar with the subject and in a position to make personal contributions to the group discussions and exercises.

During the first three days the most important issues influencing the choice of technology are discussed. Subsequently, the participants study the efficient implementation of projects. Since the participants are usually fairly conversant with the use of equipment, this focuses on how to efficiently implement labour-based projects.

A final task, collating the knowledge gained during the first three days, has been designed for the last stage of the Workshop.

This task deals with the planning, supervision and administration of a labour-based road rehabilitation programme (400 km of major rehabilitation would have to be carried out) and the organisation of the maintenance system once reconstruction had been completed.

At the end of the Workshop the participants carry out an evaluation of its contents and methodology and make suggestion concerning possible follow-up activities.

In the presentation of the course material we have attempted to follow a standard format. Each section describes the methods used in discussing the specific aspects of labour-based road construction. In general this involves a presentation by the course organiser and a number of group and individual tasks. The tasks are presented separately so that they can be easily extracted from the text. In addition suggestions are made as to the type of questions that the course organiser can put to the participants regarding the tasks.

A proposed workshop programme is shown on the following pages.

PROPOSED WORKSHOP PROGRAMME

Day One

08.30 - 09.00	Registration
09.00 - 10.00	Opening ceremony Presentation of participants Course rationale and methodology
10.00 - 10.30	Break
10.30 - 12.30	Choice of technology in road construction; advantages and disadvantages of the use of equipment and labour-based methods
14.00 - 15.30	The rural access roads programme, Kenya; the development of labour-based road construction programme
15.30 - 16.00	Break
16.00 - 18.00	Case study – the instruction of labour-based methods
Evening	Individual study task on cost estimating of rural road using equipment

Day Two

08.30 - 10.00	Group discussion of cost estimating task and comparison with labour-based construction costs
10.00 - 10.30	Break
10.30 - 12.30	Productivity; labour and equipment Recruitment procedures and incentive schemes for labour in Tanzania
14.00 - 15.30	Site planning and resource planning
15.30 - 16.00	Break
16.00 - 17.00	Site planning and resource planning

Evening Individual study tasks on

(I) priority rating exercise on planning for rural road construction;

(ii) payment procedures: Honduras case study

Day Three

08.30 - 10.15	Group discussion of priority rating task on planning of labour-based programmes
10.15 - 10.45	Break
10.45 - 12.30	Payment procedures
14.10 - 15.00	Training for labour-based road construction
15.00 - 15.30	Break
15.30 - 17.00	Handtools for road construction and maintenance
Evening	Group task on tools Individual study task on road maintenance

Day Four

08.30 - 10.00	Road maintenance; output and discussion of study task
10.00 - 10.30	Break
10.30 - 12.30	Appropriate techniques for road maintenance
14.00 - 15.00	Final task; the planning and implementation of a labour-based road construction and maintenance programme
l5.00 onwards	Participants prepare final task

Day Five

08.30 - 10.00	Group discussion of task
10.00 - 10.30	Break
10.30 - 11.30	Workshop evaluation
11.30 - 12.30	Summary

N.B. The times indicated are for illustrative purposes and should be considered as flexible.

2. PRELIMINARIES

At the beginning of a workshop it is important to thoroughly explain the organisational and administrative arrangements which have been made. A registration form giving personal particulars, expected duration of stay and details on travel and other costs incurred or to be incurred should be completed by the participants. This will avoid problems which at a later stage may adversely affect the performance of individual participants and subsequently have a negative effect on the event as a whole. On the other hand, well-made arrangements for accommodation, finance and administration definitely have a positive influence on the performance of individuals, and their importance should not be underestimated.

To break the ice among participants who may not have met before, an interviewing and presentation technique is useful. The participants are split up into groups of two. The individuals are requested to interview each other with the objective of obtaining professional profiles. Only basic information such as name, position and present duties and responsibilities is required. Each participant then presents this "profile" of his neighbour in a plenary session. This technique allows the participants to get to know each other and has the effect of creating an informal atmosphere.

An explanation of the course rationale and methodology should follow to prepare the participants for the role they will have to play during the workshop and the activities they will be expected to undertake.

3. THE CHOICE OF TECHNOLOGY IN ROAD

It is necessary to create an awareness of the fact that there are reasons to reflect upon the choice of technology and that established technologies do need to be critically examined rather than blindly accepted. One way to achieve this objective is to have a "brainstorm" on the advantages and disadvantages of the use of equipment and labour-based methods. In a plenary session all those present are asked to express their feelings, which are noted on a flipchart. A typical output of this exercise is shown below:

Advantages of equipment

1. Speed of construction
2. Good quality
3. Cheap
4. Convenient to use
5. Ease of obtaining finance
6. Well understood by engineers and supervisors

Disadvantages of equipment

1. Creates few jobs
2. Uses foreign exchange
3. Needs skilled operators
4. Difficulty to obtain spare parts
5. Needs workshops and skilled mechanics
6. Problems of transport to remote areas

Disadvantages of labour

1. Slow
2. Poor quality
3. Costly
4. Labour problems
5. High level of supervision required
6. Good handtools required
7. Draws off workers from agriculture
8. Needs different management skills
9. Payment problems

Advantages of labour

1. Uses little foreign exchange
2. Creates jobs
3. Requires few skilled operators
4. Self-reliance
5. Local manufacture development
6. Develops rural economy by putting money in hands of local people
7. Can be used on many sites concurrently

A number of remarks can be made regarding this output. It is clear that almost all of the disadvantages of labour are technical, while its advantages are socio-economic. In the socio-economic context of many developing countries it is equally clear that if the technical problems of the use of labour-based methods are overcome the use of these methods would undoubtedly be preferable to the use of equipment. Furthermore, some of the assumptions, especially the ones concerning costs, quality and speed, are often little more than preconceived ideas which deserve and will receive a lot of critical examination during the Workshop.

Since the output for the "advantages of equipment" is usually rather similar to that for the "disadvantages of labour", it will save time to omit the former. The above points can still be made.

3.1 An introduction to the Rural Access Roads Programme, Kenya[3]

Having identified the technical disadvantages of labour- based methods, a useful next step is to provide an example of a technically efficient labour-based programme. A short description of the Rural Access Roads Programme will illustrate what can be achieved when labour-based methods are applied efficiently. This Programme is the first successful attempt to use labour-based methods in road construction and maintenance on a large scale. In September 1980, approximately 3,000 km of road had been completed at an average cost of $6,000 per gravelled kilometre (some 8CC km had been gravelled). This figure includes all overheads. By the end of 1985 the programme should have constructed some 14,000 km of road in 22 districts of Kenya. In September 1980 the Programme employed 10,000 casual workers, 120 supervisors and 14 engineers. All roads are maintained using labour-based methods. The maintenance is done by individual "contracts" by people living in the immediate vicinity of the road. The maintenance payments are made "by results", i.e. if the contract is not fulfilled (the road is in a bad condition) no payments are made.

This short presentation serves to seriously question some of the assumptions regarding low speed, poor quality and high cost of road construction using labour. It should be emphasised that the reason why this large-scale Programme is still running efficiently is basically because its organisation and administration were specially designed for and adapted to the use of labour-based methods.

3.2 CASE STUDY: The introduction of labour-based methods

This case study highlights the problems that can be expected when the objectives of a project and the ways to achieve these objectives are not clearly defined. The study should in no way be construed as being a criticism of the rural roads programme, which in itself is an extremely efficient programme which is now building high-quality gravel roads at a reasonable cost. However, it does show how it was possible that a programme which set out to be “as labour-intensive as possible” changed into an entirely equipment-intensive project.

The rural road project

(a) Design and selection criteria

When the project was started in 1973 the project designers stated that “the rural roads programme will consist of a series of relatively short and cheap stretches of road”. Although it was envisaged that some major access roads would be constructed under the programme, it was made clear that the emphasis would be on the ungazetted (i.e. unclassified) road network. It was expected that the roads would be single-lane pavement of 4 metres width.

Unfortunateiy, the project document did not lay down any criteria for selection and consequently the roads constructed have generally been those that were most needed in the eyes of the district councils. That in some cases these have been roads which it would be hard to classify as rural roads is perhaps not surprising.

[3] For a detailed description of this Programmer its development, administration and organisation, see "The Rural Access Road Programme", by J.J. de Veen, op. cit.

(b) Construction methods

The project designers stated quite clearly that the project should utilise labour-intensive methods to the fullest extent possible taking into account the required standards and the economic viability of these methods. They proposed that the first project to be constructed should be used as a pilot project to assess for which activities labour-intensive methods could be used. Nevertheless, it was also agreed that this project should be supplied with one bulldozer, 2 rollers, one grader, 15 tractors and 12 trailers and assorted water pumps, mixers, etc. Consequently, the project was in the happy position that, if the labour-intensive methods did not work, equipment was available. Moreover, the next (at that time) six teams envisaged were already planned to be provided with a similar amount of equipment.

The pilot project was the construction of an important arterial link leading to the district capital which in fact is the main road in Kweneng district. An evaluation was carried out on the use of labour-intensive methods. However, the data was never recorded in a systematic fashion so that it is now impossible to make any assessment of this evaluation. By all accounts, however, there was enthusiasm for the use of these methods particularly with regard to their flexibility in the face of repeated breakdowns of equipment. It was felt that at the wage rate then prevailing (US$1), the methods were viable for the clearing and grubbing operations, loading of gravel, and to a lesser extent ditching. It should be pointed out, however, that the actual design of the road, in particular the ditches, was not revised to suit the labour-based methods nor was it possible to provide the detailed supervision that is necessary for labour-intensive methods.

In mid-1974 the wage rate vas increased from US$1 to US$2.5 per day. Clearly this had an influence on the economic viability of labour-intensive methods. Problems also arose due to the fact that equipment was working in close proximity to labour. On the one hand, it was clear that for a particular operation the piece of equipment could work much faster than the labour; on the other hand, the labourers must have been somewhat disillusioned when they saw the equipment working faster.

An evaluation mission visited the project in November 1975 and noted that labour-intensive methods had been introduced to only a limited extent. They noted also that because the supervisory staff vas expatriate there was a tendency to consider labour-intensive methods as something inferior. It was suggested that a separate research element should be introduced into the project to assess the real viability of labour-intensive methods.

The lack of supervision on the site and further increases in the wage rate meant that the argument against labour-intensive methods became even stronger. In 1977, it was decided that all roads constructed by the Ministry of Works under the rural roads project would be executed using equipment-intensive methods.

We will now look at the arguments used for the switch to a reliance on equipment.

First, there is the argument that the wage rate was too high for labour-intensive methods to be viable. This argument, however, was not supported by any detailed evaluation. Furthermore, a strong case could be made for reducing the wage rate for unskilled workers hired under the project. There was a precedent for this in that

district councils had been permitted by presidential decree on other occasions to employ unskilled labour at a reduced rate based on the national minimum wage rate of US$0.20 per hour. Discussions in the field indicated that small contractors had no problems in obtaining labour at this reduced rate.

Second, there was the argument that labour-intensive methods did not meet the required standard. This is easily disposed of: the quality of well-supervised labour-based activities has been proven to be by no means inferior to those carried out by machines. In any case, labour-based methods can always be used for those activities which have no impact on quality, for example earthworks which normally account for a large proportion of the total amount of work.

Third, it was argued that the use of labour-intensive methods would slow down the progress of the work. In this regard, it is interesting to compare the progress of this project with that of the Rural Access Roads Programme (BAFP) in Kenya. That programme is also producing 4-metre gravel roads but using predominantly labour-intensive methods. Whilst the comparison may not be totally justified, it is worth noting that the average production of EAEP units is approximately 40 km of road per year. In 1977, the four units of the Botswana rural roads programme produced 142, i.e. an average of 37. In a period of 50 months, the RARP has produced a total of 1,235 km of road of which 220 km had been gravelled. It would be unfair to take the comparison too far. Suffice it to say that, at the very least, the argument regarding increased duration would be hard to justify.

Fourth, it was argued that there was insufficient supervisory staff to implement the use of labour-intensive methods. This was perfectly correct. It will definitely be necessary to set up a course specifically geared to the supervision of labour-intensive methods.

The rural roads project being administered by the Ministry of Works and Communications has now become a fairly traditional equipment-intensive programme even though it was intended that it should utilise labour-intensive methods and that the roads should generally be true rural roads.

(c) Problems for the future

At present, the policy in the country is that roads are constructed by MOW with relatively equipment-intensive methods. Unless it is found possible to obtain more data on productivity and quality of labour-based methods in different areas in the country this policy is not likely to change quickly.

It should not, however, be felt that this choice has no problems whatever. In particular, it is worth discussing the question of training, maintenance of equipment and construction costs.

Training. In theory, the road training centre runs four courses, three for supervisory staff and one for plant operators. However, in 1978 only one course was operational which would at the earliest deliver 17 technicians in 1981 (three-year course).

In 1978 the rural roads programme had only four Botswanans in a supervisory capacity, i.e. road section officers. For the next two years no new supervisors would become available for the project.

Maintenance of equipment. As reported by the project, the utilisation rates for equipment are high. This is principally due to the presence of expatriate mechanics on the project capable of being moved from one site to another. The cost of these mechanics is high and is presently being paid out of external aid funds. When these funds dry up the mechanics will leave Botswana and no Botswanan mechanics of comparable experience will be available.

Construction costs. According to the 1977 annual report, the accumulated expenditure to the end of 1977 was approximately US$5 million. This figure excludes the cost of expatriate personnel. By the end of 1977, 250 km of road had been completed at an average cost of US$20,000 per km. In 1977, the output increased considerably to reach 143 km of road constructed at a direct[4] cost of US$12,000 per km.

Two important aspects (i) supervisory costs and (ii) actual equipment costs should, however, be included to arrive at a more realistic cost per kilometre:

(i) Supervisory cost: during 1977 the project had 137 man-months of expatriate supervision. This supervision cost US$2,000/km, amounting to some 14 per cent of the overall cost.
(ii) Equipment costs: as the equipment was provided to the project by an external agency, the initial costs were not included in the direct cost per km quoted above. Only the running and maintenance costs were included.

Discussion

Concerning this case study, the following questions can be posed to be discussed in groups:

1. What were the main reasons for the shift in the project objectives, i.e. construction of major rural roads with equipment instead of selected improvement of the ungazetted road network?
2. Can you give a realistic cost/hour estimate for a grader, bulldozer D6 and tractor in your country? The figures should include:
   (i) replacement costs assuming a life of five years (20 per cent write-off per year);
   (ii) running costs (maintenance, repair, fuel and operating personnel costs).

On question 1 the following output may be expected and can be discussed in a plenary session:

Question 1

- no previous experience with use of labour-based methods, therefore no detailed planning and organisation;
- lack of supervisory personnel;
- unfamiliarity of expatriates with these methods;
- high wage rates;
- no defined selection criteria;

[4] Excluding overheads, expatriate personnel costs and I initial purchase costs of equipment.

- provision of machines, prejudging choice of technology;
- no documentation of experiments on labour-based methods;
- own supply of mechanics and spare parts;
- prejudice against the use of labour-intensive methods.

Question 2 provides an opportunity to introduce the individual study task for the evening dealing with costing techniques and assumptions to be made regarding utilisation rates, productivity and purchase/capital costs of different pieces of equipment.

It is our experience that many engineers, particularly those in government service, have difficulty in calculating actual equipment costs. They are used to receiving hire rates from their plant department. These, of course, are usually subsidised and do not reflect the true cost.

Usually, therefore, the figures obtained from and assumptions made by participants vary enormously, by usually more than 100 per cent. This enables the trainer to emphasise the extreme importance of making valid assumptions before using them in cost calculations or cost comparisons.

3.3 TASK: Cost estimates for rural road construction

The government of a particular country has decided to set up a rural road programme to construct 200 km of road in an area 250 km from the main harbour where all equipment for the programme is located. The programme will be carried out directly by the Ministry of Works.

The terrain in the area where the programme will be carried out has sandy/firm soil and is covered with dense vegetation. No trees/bush of a diameter greater than 10 cm or boulders with a diameter greater than 1 m will be encountered. A layer of 10 cm topsoil has to be removed. The construction has to be carried out in sidelong ground and the average volume of excavation is 4,000 cubic metres per kilometre.

The cross-section required is as shown in figure 1. Only one ditch of 1.40 width must be provided.

Since the gradients do not exceed 10 per cent, hauling in the longitudinal direction of the road is limited to a maximum of 25 metres. On average, five culverts per kilometre will be required. The cost of one culvert ring of 60 cm diameter and 1 m length is US$10. We assume that:

(a) the number of unworkable days (public holidays, Sundays, rain) is 115per year;
(b) at the beginning of the project all equipment needs to be transported 250 km to the project site;
(c) the area has no workshop with equipment maintenance facilities;
(d) the necessary clearing width is 8 metres; the removal of 10 cm of topsoil amounts therefore to 800 m^3/km;
(e) culverts are manufactured at one or more central points and need to be transported an average of 20 km (one way) to the crossings;

(f) the ditch area is 0.4m^2 so that 400 cubic metres per km will have to be removed for a one-side ditch (one pass of the grader will be sufficient);
(g) at least four passes of the grader will be required for the shaping and the camber formation;
(h) no mechanical compaction or gravelling is carried out by the programme;
(i) in principle, the earthworks, ditching and camber formation can be carried out with dozer(s) -(D6) and grader (s). You are free to choose the number of machines (assume the following cost per hour -D6 US$50, grader US$25);
(j) for supervision and transport of construction materials, one flat lorry and one 4-wheel-drive vehicle are sufficient. A low-loader will be needed to transport the heavy equipment. This low-loader is based in the main harbour and at the completion of the job the machines will be transported back there (assume the following costs: lorry US$15/hr, 4-wheel-drive US$10/hr, low-loader US$2/km).

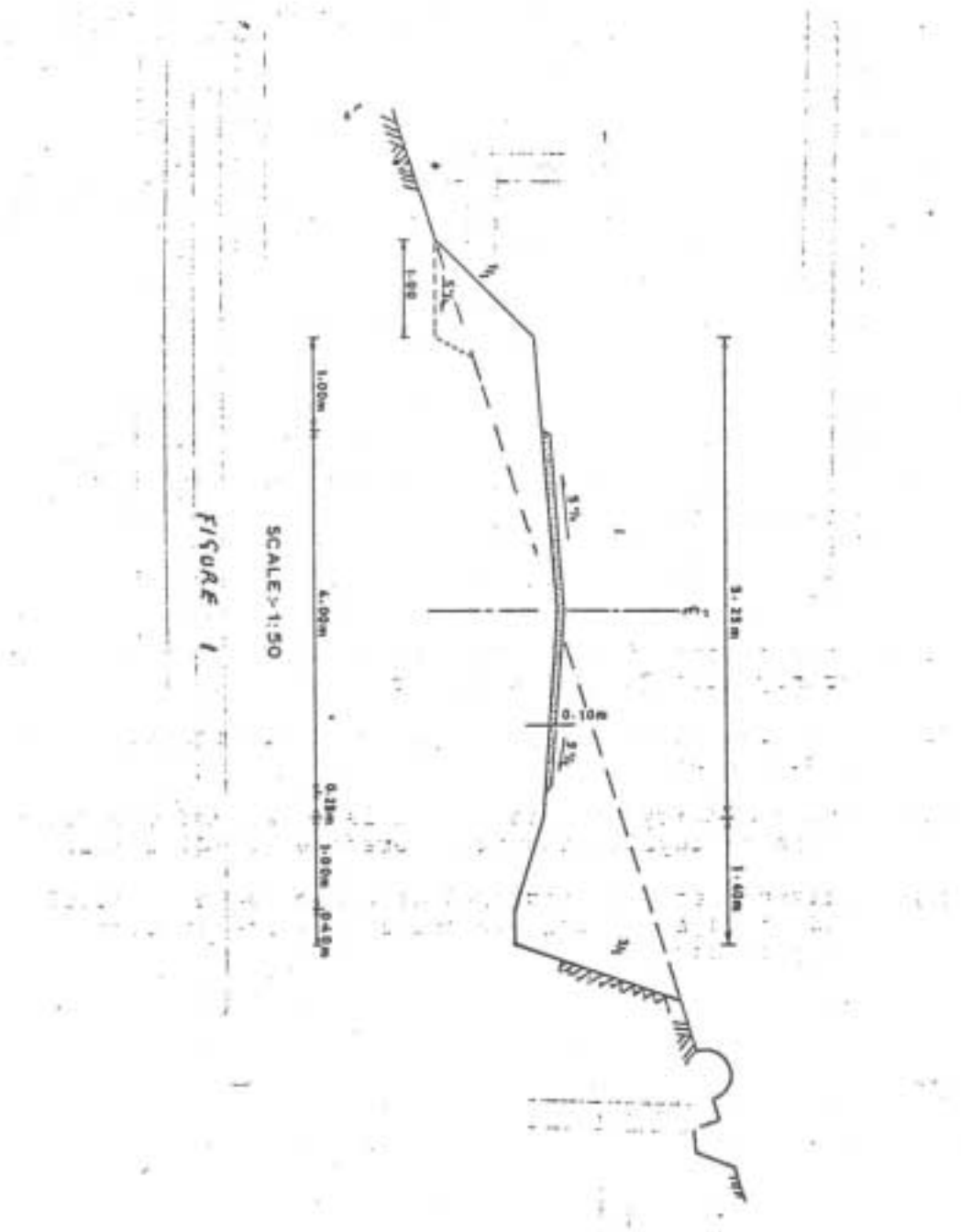


FIGURE 1

Please calculate roughly:

1. the construction cost per kilometre if one road with a length of 200 km is to be constructed;
2. the construction time required with the number of machines chosen.

Please carry out the following steps before you make your calculations:

(i) Assume a utilisation rate for (a) bulldozer (D6), (b) grader in a number of effective working hours per year. For example: since we have assumed that 115 days per year should be written off as impossible to work (rain. public holidays), the maximum number of effective working hours per year (8-hour working day) would be 8 x 250 = 2,000 hours. However, this would imply that on average the machine works eight hours per day, never breaks down, is never transported and does not need any maintenance. You are asked therefore to realistically assume how many hours per year the machine can be expected to work taking all the above factors into account. Assume that the machines are two years old at the start of the project.

(ii) Assume costs per km for (a) labour, (b) the construction of camps, (c) tools and materials, (d) supervision and administration. Add these figures to arrive at an overall cost per kilometre for these items.

(iii) Assume outputs for the dozer D6 (in cubic metres per hour) and grader (in kilometres per day). Take care that the outputs are assumed for heavy construction work in sidelong ground.

Notes

- The initial costs of setting up a workshop for the repair of graders/bulldozers is US$50,000.
- The running and overhead costs of a workshop to repair graders/bulldozers amount to US$10,000 per year.
- The training of the necessary supervisory and operating personnel costs US$5,000 per trainee.

Discussion

It is very illustrative to put up the different assumptions of utilisation rates (step 1), productivities (step 2) and overhead costs per kilometre (step 3) on a blackboard or flipchart. The variations are usually enormous, reflecting the fact that in many cases government engineers are not used to doing this type of calculation. At this point it should be emphasised once more that the person responsible for choosing a technology in particular circumstances should endeavour to determine the costs of the alternatives by making realistic assumptions of utilisation, productivities and other costs involved.

The task solution given below is based on World Bank and ILO research work and also reflect experience with average utilisation of equipment in various government institutions in Africa.

The fact that machines often have to be utilised in difficult circumstances in remote areas is partly taken into account but it can safely be assumed that often the actual utilisation rates will be lower than those mentioned below. Of course, much depends on the supply of spare parts, the accessibility of the area of work, .the proximity of workshops and the skills of operators and mechanics.

Task Solution

(1) Utilisation rates: Dozer and grader - <u>1.250 hours/year</u> (Average utilisation 5 hours per day in a 250 working day year).

(2) Cost per kilometre:

Labour	US$300
Camps	US$100
Tools and materials	US$100
Supervision and administration	US$900
Total	US$1,400/km

(3) Productivities: Dozer (D6) 75 m^3/hr
Grader 2 km/day
(Sidelong ground and doing construction work).

(4) (a) Quantities of work per kilometre (see task):

Clearing	8 x 0.1 x 1,000	= 8CC m^3
Ditching	0.4 x 1,000	= 400 m^3
Excavation		4,000 m^3

(b) Time required in hours:

Clearing (D6)	$\frac{800 \times 200}{75}$	= 2,133)		
Excavation (D6)	$\frac{4,000 \times 200}{75}$	= 10,667)	)	12,800
Ditching)	Grader	$\frac{5 \times 200}{0.25}$	=	4,000
Camber formation)				

Number of machines chosen: 3 D6 + 1 grader.

Construction time: 12,800/3 = 4,266 hrs:

at 1,250 hrs./year = 3.4 years

(c) Total cost for the construction of 200 km:

Labour $300 x 200	60,000
Transport $2 x 500 x 4 x 2	8,000
Clearing $50 x 2,133	106,650
Excavation $50 x 10,667	533,350
Ditching and camber $25 x 4,000	100,000
Workshop (initial cost)	50,000
Workshop (running costs) $10,000 x 3.4	34,000
Site accommodation (camps) $100 x 200	20,000
Tools and materials $100 x 200	20,000
Supervision and administration $900 x 200	180,000
Operator and supervisor training (say 10) $5,000 x 10	50,000
Culverts (7 rings per line) $10 x 5 x 7 x 200	70,000
Lorry 4,000 x $15	60,000
Pick-up 4,000 x $10	40,000
Total	$1,332,000

Cost per-kilometre $\frac{\$1,332,000}{200}$ = $\frac{6,660}{}$

Using the average productivity figures for labour achieved in Kenya as described in "The Rural Access Programme, Appropriate Technology in Kenya", the following construction cost estimate can be made for the same road being constructed with labour-based methods:

Man-days per kilometre

Activities	Quantity	Rate	Man-days/km
Setting out	1 000 m		5
Bush clearing	8 000 m^2	320 m^2/MD	25
Topsoil stripping	800 m^3	4 m^3/MD	200
Stump/boulder removal	–	–	200
Excavation to level	4 000 m^3	4 m^3/MD	1 000
Slotting	–	–	50
Ditching	400 m^3	3 m^3/MD	135
Camber formation	400 m^3	10 m^3/MD	40
Culvert installation	5 lines/km	10MD/line	50
Scour checks	50/km	–	10
Catchwater drains	500 m	–	20
Subtotal :		1 735	
Plus 15% contingencies :		260	
Total man-days/km :		1 995	(say 2 000)

Cost per kilometre		**Cost assumptions**
Labour (2,000 man-days x $2/day)	4 000	–
Culvert rings (35 x $10)	350	(same as equipment)
Lorry	300	(same as equipment)
Pick-up	200	
Tools and materials	250	(2 ½ times equipment)
Training	250	(same as operator's and supervisor's equipment)
Overheads (supervision and administration)	1 350	(1 ½ times equipment)
Site accommodation	100	(same as equipment)
Total cost/km	6 800	

The construction time naturally depends on the number of labourers employed. The total number of man-days required for the 200 km is 200 x 2,000 = 400,000. If ten construction sites were operating along the road, each employing 80 labourers, 500 construction days would be required for the construction of the road. It should be recognised of course that the above-quoted labour productivity rates have been

achieved on well-planned, organised and supervised construction sites, where labour is motivated with time bonuses (task work).

It can be seen that the costs per kilometre for labour and machines are quite close (US$6,800 versus US$6,660) for the assumptions made. It is also clear, however, that changes in (equipment or labour) productivity have an enormous influence on these figures. As mentioned above, the equipment utilisation and productivity rate can be assumed to be lower in remote inaccessible areas. Labour productivity on the other hand is far more dependent on the site organisation and incentive schemes used. A study on equipment productivity rates in the Philippines has shown that the actually achieved average productivity rates on site are only some 25 per cent of the rates quoted in the manufacturers' brochures.[5]

In order to illustrate how equipment costs can be calculated, an example can be handed out of a calculation of the hourly cost of a caterpillar D8 (1978 prices) operating on the songea-Makambako Road in Tanzania (table 1). The costs are calculated following an established World Bank procedure and it can be seen that even in 1978 the hourly cost of a D8 was approximately $65. Note that this cost does not consider the rate of inflation, which has an enormous influence on equipment prices. For example the cost of a D8 now is 2.5 times the cost of a D8 ten years ago. If therefore the machine is to be replaced after it has outlived its useful life a realistic provision for replacement funds will have to be made. For this reason rates of inflation should be taken into account.

Table 1: Equipment costing Sonqea-Makambako Road, Tanzania

Equipment: Caterpillar D8K
Weight: 31,700 kg
Life: 12,000 hrs
Annual util: 1,500 hrs
Repair factor: 0.135 (Annual)

15% Discount
All prices in Tanzanian shillings (1978 prices)
Assume US$1 = 8 Tanz. sh.

		US$ (approx.)	**Tsh**.
1.	In factory price	191 000	1 528 117 /–
2.	Customs duties	Nil	Nil
3.	Handling charges, port fees and dealers' margin	4 900	39 183 /–
4.	Delivered price	195 900	1 567 300 /–
5.	Transport to site	5 200	41 682 /–
6.	Salvage value	Nil	Nil
7.	Capital cost	201 100	1 608 982 /–
8.	Capital recovery factor	0.22285	0.22285
9.	HOURLY DEPRECIATION COST	29.9	239 / 041
10.	Insurance (m = 0.555)	0.72	5 / 79
11.	Maintenance and repairs	18.1	144 / 80
12.	Fuel and lubricants	15.4	123 / 22
13.	Tyre or track costs	0.61	4/89
14.	HOURLY OPERATING COST	34.83	278 / 72
15.	Special items	–	–
16.	DIRECT HOUFLY RENTAL COST (Excluding operator's wages)	64.73	517 / 76

[5] See D. Lal, Men or Machines, op. cit.

Notes: All equipment data from manufacturer in Dar es Salaam
Diesel consumption = 40.9 litres/hr,
tracks cost = 19,070, track life = 4,000 hours,

repair factor = $\frac{0.09}{1{,}000}$ x annual utilisation

handling charges,etc. = 2.5% of delivered price.

The capital recovery factor is based on the following formula:

$$\frac{i\,(1+i)^n}{(1+i)^n - 1}$$

i = interest rate (15%)

n = $\frac{12{,}000}{1{,}500}$ = 8

In this case equipment replacement is supposed to take place after 8 years.

However, as noted above, this way of calculating costs is still not completely realistic as it does not consider the increased replacement costs of the machine after a number of years. This formula represents both the opportunity cost of investing in a piece of equipment rather than putting the money in the bank and also the fact that it will be necessary to replace the machine after … years.

The following calculations illustrate how an hourly cost for a piece of equipment is calculated when s11 costs related to the ownership and operation of the equipment are taken into account. After this demonstration the participants could work out a simple example in order to familiarise themselves with the calculation method used.

The costs taken into account are:

(i) depreciation and replacement;
(ii) investment costs;
(iii) maintenance and repairs (including insurance, tyres, tracks);
(iv) fuel and lubricants.

(i) Depreciation and replacement

We assume that the machine will be written off in eight years and will have no salvage value at the end of year 8. Furthermore, we assume that the purchase price of the machine increases by $20,000 per year (10 per cent of the initial purchase price). Table 2 shows the steps to be taken. Column 2 illustrates how much it would cost to replace the machine at the end of each subsequent year. Column 3 shows the salvage value, which is calculated by deducting the depreciation from the initial purchase cost of $200,000. The depreciation method used recognises that more depreciation should be charged when a machine is new. The calculation of the first year's depreciation for a machine worth $200,000 with a life of eight years is:

$$\frac{8}{(8+7+6+5+4+3+2+1)} \times \$200{,}000 = \$44{,}444$$

Eighth and final year's depreciation:

$$\frac{1}{36} \times \$200{,}000 = \$5{,}555$$

Table 2: Depreciation and replacement cost

(in dollars)

1	2	3	4	5	6	7
End of year	**Replacement cost**	**Salvage value**	**Loss on replacement**	**Hours of use**	**Cumulative hours of use**	**Cumulative cost per hour (4 divided by 6)**
0	200 000	200 000	Nil	-	-	-
1	220 000	155 555	64 445	1 500	1 500	42.96
2	240 000	116 667	123 333	1 400	2 900	42.52
3	260 000	83 334	176 666	1 300	4 200	42.06
4	280 000	55 555	224 445	1 200	5 400	41.56
5	300 000	33 333	266 667	1 100	6 500	41.02
6	320 000	16 666	303 334	1 000	7 500	40.44
7	340 000	5 555	334 445	900	8 400	39.81
8	360 000	Nil	360 000	800	9 200	39.13

Table 3: Investment cost

(in dollars)

1	2	3	4	5	6	7	8
Year	**Investment start of year**	**Depreciation**	**Investment end of year**	**Investment cost**	**Cumulative investment cost**	**Cumulative use (hours)**	**Cumulative cost per hour**
1	200 000	44 445	155 555	30 000	30 000	1 500	20.00
2	155 555	38 888	116 667	23 333	53 333	2 900	18.39
3	116 667	33 333	83 334	17 500	70 833	4 200	16.86
4	83 334	27 779	55 555	12 500	83 333	5 400	15.43
5	55 555	22 222	33 333	8 333	91 666	6 500	14.10
6	33 333	16 667	16 666	5 000	96 666	7 500	12.88
7	16 666	11 111	5 555	2 500	99 166	8 400	11.80
8	5 555	5 555	Nil	833	100 000	9 200	10.87

(ii) Investment costs

Instead of buying the machine, the buyer could have used his money differently. For example, he could have deposited it in a bank, thereby receiving a yearly amount of interest on his capital. If he had done this in year one at an interest rate of 15 per cent, he could have gained $200,000 x 0.15 = $30,000 (column 5, table 3). If he had sold his machine at the end of year one and deposited his money for one year he could have gained $155,555 x 0.15 = $23,333. These costs can be expressed in a cost per hour (see column 8).

Total despreciation and investment cost

Adding the columns 8 of tables 2 and 3 gives us hourly depreciation costs for each year.

Table 4 : Depreciation and investment cost

Year	1	2	3	4	5	6	7	8
Hourly depr. cost	62.96	60.91	58.92	56.99	55.12	53.32	51.61	50.00

(iii) and (iv)Maintenance and repairs, fuel and lubricants

Because we have assumed higher depreciation costs in the first years the hourly costs are higher in the be9inning than at the end of the eight-year period. In practice this will be balanced however by the increasing costs of maintenance and repairs as the machine gets older. The assumptions made concerning costs of maintenance, repair, fuel, tracks and insurance for a Dozer D8 operating on the Songea-Makambako Road in Tanzania will now be used to arrive at an average hourly cost. In this simple example an average cost for maintenance, repairs, fuel and lubricants has been used. A more rigid analysis would assess the increasing cost over the life of the equipment.

(v) Total hourly costs for a D8:

Average depreciation and replacement (table 4) $\frac{62.96 + 60.91 + 58.92 + 56.99 + 55.12 + 53.32 + 51.61 + 50}{8} = \underline{56.22}$

Maintenance and repairs (incl. insurance, tracks) (see table 1) $\frac{144.80^1 + 5.79^1 + 4.89^1}{8} = \underline{19.43}$

Fuel and lubricants $\underline{123.22^1} = \underline{15.40}$

Total hourly

costs of D8 = 91.05

[1] Tanzanian shillings (1US$ = 8 T.sh)
This figure does not include operator's wages.

We have used the figure of US$200,000 for our calculations. For comparison it may be noted that in December 1980 Caterpillar quoted the following approximate prices:

D8	US$230,000
D6	US$125,000
Motorgrader 140C	US$120,000

It should be noted that these prices are "ex-factory" and that transport costs to the place of destination are usually considerable (US$10,000 was quoted for the transport of a D6 to East Africa).[5]

[5] Comprehensive discussions of equipment lists can also be found in the following publications:
(a) R. Pellrifoy, Construction planning, equipment and methods, McGraw-Hill, New York, 1956 (70).
(b) M. Allal and G.A. Edmonds, Manual on the planning of labour-intensive road construction, ILO, Geneva, 1977.
(c) W.A. McCleary et al., Equipment versus employment, ILO, Geneva, 1976.

4 RECRUITMENT AND USE OF INCENTIVE SCHEMES

To get an idea of the recruitment procedures and the possibility to use various types of incentive schemes in a particular country, the following. questions need to be discussed:

- In what ways can labour be employed by the Government for construction projects?
- What wage rates are paid to the above categories of labourers?
- What incentive schemes can be used to improve the productivity of labourers,

The first question should give an indication of the flexibility of the government recruitment system. Some possible ways of employment are: (i) permanent, (ii) semi-permanent, (iii) casual, (iv) village contracts, (v) individual contracts.

As far as the third question is concerned, ILO studies have clearly indicated that workers paid on a piece- or task- rate system produce a much higher output than daily-paid workers. It is recommended to use the daily payment system only when no productivity data are available. As soon as enough data has been assembled the task-work system should be applied. Here a fixed daily wage is given in return for a fixed quantity of work. Tasks can be given to individuals or groups of workers.

In India labour contractors use a piece-work system in which the worker is paid a fixed sum per unit of output, e.g. US$1 per cubic metre of soil. It is usually quite difficult to introduce such a system for government work as a non-fixed daily wage is usually not acceptable to a government agency. Furthermore, if the money is not provided by the persons who measure the output (contractors yes, government no), the scope for corrupt practices is great. Finally, the administration and measurements by the supervisory staff are much more complicated and imply quite a lot of extra work.

The need to establish fair task rates for different activities carried out in different conditions needs to be emphasised. Work studies are usually necessary to determine such task rates.

Finally, it should be emphasised that good site organisation (everybody knows what to do, has enough space and the right tools and materials) as well as proper supervision have a strong positive influence on productivity.

5 PLANNING

Planning is greatly facilitated by the establishment of task rates, which in turn have a positive influence on motivation and productivity. Before the group task on site and resource planning is introduced it is useful to go through the major steps to be taken when a labour-based road construction project is planned.

Step	Activity
1	Establish the quantities of work to be done (bill of quantity or quantity estimate).
2	Determine or estimate the average task rates for each activity.
3	Determine the total number of man-days required.
4	Determine how many labourers will be employed.
5	Divide 3 by 4 to arrive at the number of construction days required to complete the works.

Emphasise that not all labourers should start on the same day but that the labour force should be gradually built up to reach its total strength only after one or two weeks of operation. This will avoid confusion and organisation problems and will contribute greatly to the efficient implementation of the various activities.

As an example of a planning method the “Time and Location Chart” can be discussed and the description below can be handed out to the participants. This chart not only visualises the timing and quantities of the work but also shows the location of the various activities to be carried out.

Description of a time and location chart

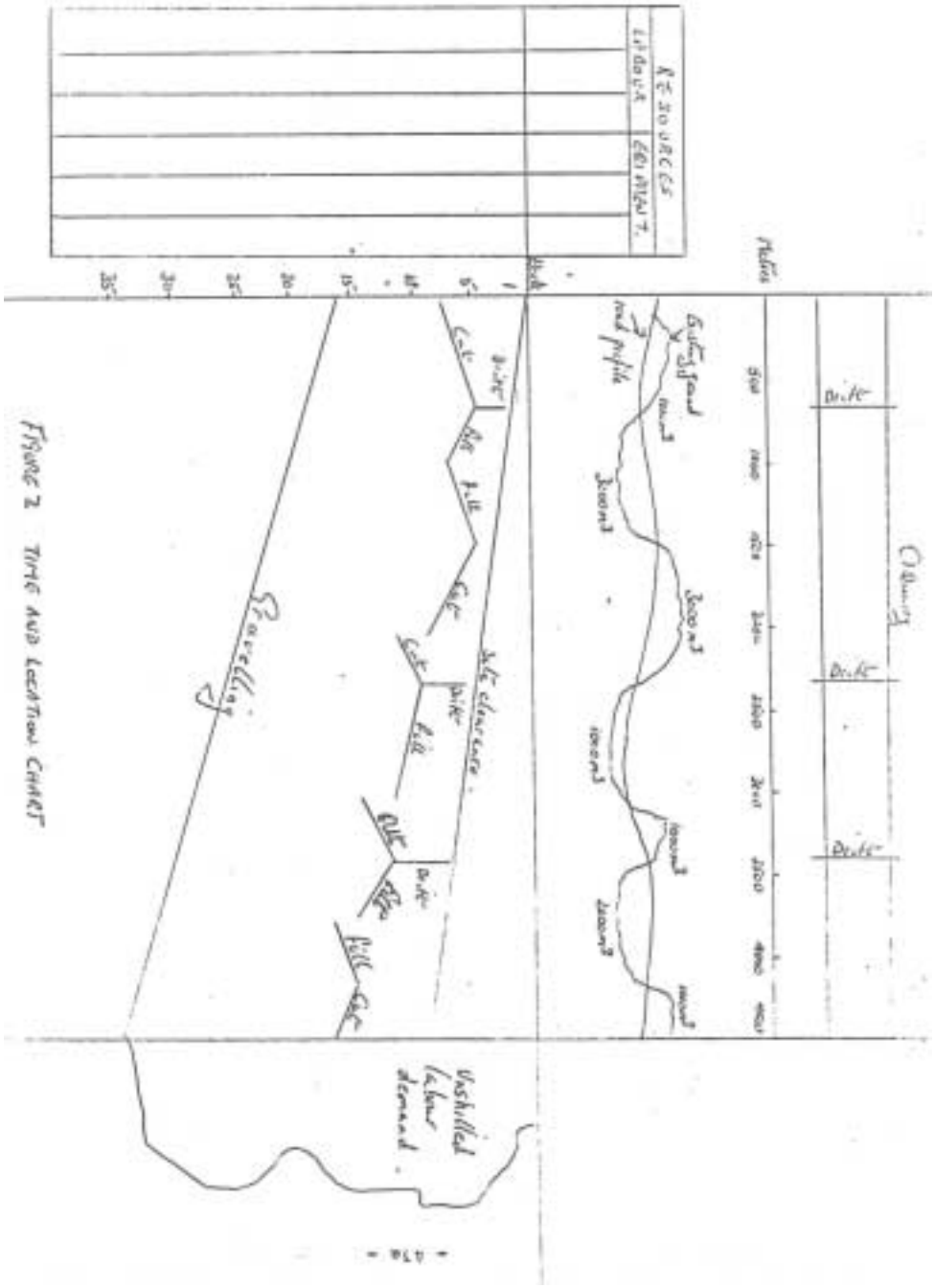
This diagram is a graphical representation of the major constituents of the road project (see figure 2).

(i) The plan of the road is drawn at the top of the diagram. The chainage points are marked, as are all the structures such as bridges, culverts and retaining walls.
(ii) The longitudinal section of the road is drawn under the plan, volumes of cut and fill are marked on this longitudinal sector.
(iii) The horizontal axis of the diagram represents the length of the project and is a direct projection of the longitudinal plan. The vertical axis is on a timescale and can be in construction days, weeks or months as required. Each operation is drawn on the diagram as a series of lines and each point on the line represents a point in time and location.
(iv) At the left-hand side of the diagram the resources required in terms of labour and equipment can be shown (calculated by reading across the row and adding the resources required to each operation at each point of time).
(v) These data enable the planner to plot a labour demand curve as shown at the right-hand side of the diagram, on which the expected labour supply curve can be superimposed.

It should be noted that this example illustrates the main elements of a critical path network without using network diagrams, e.g. the cut and fill operation between chainage 600 and chainage 1,000 cannot be effectively executed until the culvert at chainage 700 is completed.

Since the diagram shows hauling lengths as well it is also possible to tell at a glance which hauling technique (wheelbarrows, tractor trailers, dump trucks) is the most appropriate for a particular cut to fill operation.

A lot of variations are possible and the chart can be made as simple or detailed as the, circumstances require. This is particularly important, as in labour-intensive programmes not only higher-qualified personnel deal with planning and control but also construction supervisors of a low educational level.



5.1 TASK: Site and resource planning

Planning is necessary to ensure that an optimum use is made of the available resources. In the case of road construction, these resources can usually be classified as human (various categories of personnel), equipment (including handtools) and materials (construction and administration).

A recommended way of planning is to proceed as follows:
step 1: what has to be done?
step 2: how should it be done?
step 3: who will be responsible for which activities?
step 4: where should it be done?
step 5: when should it be done?

When answering these questions, ask yourself in each case: why should it be done this way, and are there better ways to achieve the objectives? Sometimes two alternative solutions will have to be examined in detail and advantages/disadvantages weighed before the best choice can be made. Always explain and justify why you have made a particular choice.

The following task is on planning for a labour-based road construction job.

Data
A road is to be constructed using labour-based methods. It will be gravelled making use of tractor/trailer combinations and manpower to excavate/load/spread. The road is to be constructed in a remote area where no existing facilities (offices, camps, etc.) are available.

The following supervisory/administrative staff are available: engineer, supervisor in charge of earth road construction, supervisor in charge of gravelling, pay clerk, mechanic, carpenter, storekeeper (mainstore), storekeeper (site store), headman.

Question 1
List the various preparatory activities to be carried out before the construction can start. Indicate who will be responsible for each activity.

Question 2
List the activities to be carried out during the construction/gravelling period.

Question 3
Make a timetable in construction days using the data given below. This timetable should cover the preparatory activities as well as the execution of the construction and gravelling activities.

Length 10 km

Number of labourers available 100

Quantity of work to be done

Clearing and grubbing 80 000 m^2

Excavation to level	40 000 m^3
Ditching	4 000 m^3
D Other drainage work	1 000 man-days
Camber formation and shaping	750 man-days
Gravelling	6 000 man-days
Number of tractors available	5
Average hauling distance quarry/site	5 km
Average number of trips per tractor per day	7
Length gravelled per load	5 m
Productivity per man-day	
Clearing and grubbing	80 m^2
Excavation to level	4 m^3
Ditching	4 m^3

Discussion

The site and resource planning task will provide the basis for the participants to carry out the priority rating exercise (see below), as they will have listed most of the preparatory and construction activities already. The priority rating exercise should first be done on an individual basis, then agreed upon in groups, after which the results can be compared in a plenary session with the designer's solution which is given below.[1 6]

The first exercise is meant to determine the logical order of the activities carried out by headquarters before the start of the construction activities. The second exercise is to rate the activities to be carried out by the site engineer/supervisor.

Note that, in exercise A (HQ level), the training of supervisors cannot be started before the programming reporting, procurement and payment procedures have been designed as these procedures should be included in the curricula of the supervisory staff training courses.

5.2 TASK: Priority rating

Below you will find a number of activities which need to be carried out when a road is to be constructed. The activities are arranged in random order. It is the intention that you indicate in which order or priority these activities should be carried out by putting numbers from 1 upwards in the boxes corresponding to the activities.

[6] *Exercise A (HQ level):* 7, 6, 2, 12, 8, 1, 9, 10, 5, 15, 4, 3, 11, 14, 13.
Note: Activities 12/13/14 are carried out more or less simultaneously and are thus interchangeable. The rating of activity 5 is arguable.
Exercise B (site level): 15, 8, 12, 14, 11, 5, 1, 13, 2, 4, 6, 3, 9, 10, 7.

The first row of boxes immediately next to the text should be completed on an individual basis. The second row should be completed as a team exercise, discussing the priority rating of the various activities until agreement has been reached. The third row will be completed in a plenary session in which the various group results will be compared.

Carry out this exercise in two stages: first complete exercise A, then exercise B.

Exercise A HQ level	**Priority rating**			
	*	**	***	****
Determine what the organisational structure for the implementation of the project should be				
Make a general workplan, specifying targets to achieve and resources to be used				
Find out which design standards are to be adopted for the project				
Order tools and materials				
Determine who is responsible for what within the project organisational structure				
Find out the objectives of the project				
Estimate the demand for supervisory staff, labour, tools, materials and equipment (time/place)				

Ensure that adequate office and storage facilities are available				
Determine if, and if so how, the project is related to other government projects in the area				
Implement training courses for supervisory personnel				
Determine whether the road will be constructed using mainly labour or mainly equipment-based methods				
Assess whether labour is available in the project area				
Set up system for the procurement, handling and storing of tools and materials				
Set up site programming and reporting systems				
Set up payment procedures for the casual labour and other staff				

Total column 4

* To be completed on an individual basis

** To be completed in a group exercise

*** To be completed in a plenary session

Exercise B Site level	**Priority rating**			
	*	**	***	****
Check filling of daily/weekly report forms				
Construct site camp				
Recruit labour for construction				
Inspect work carried out				
Make detailed workplan for week one				
Determine the requirements of labour and stores				
Carry out first survey to determine the road alignment				
Start first construction activity				
Carry out technical appraisal to provide bill of quantity				
Make over-all workplan specifying how many man-days and how many labourers are to be used				
Determine the size and location of the site camp				
Estimate average productivity rate for each activity				
Transport stores and materials to the site camp				
Set out the alignment and road levels				
Recruit labour for site camp construction and setting out				

Total column 4

* To be completed on an individual basis

** To be completed in a group exercise

*** To be completed in a plenary session

6 PAYMENT OF WORKERS

An important aspect of labour-based construction/maintenance works is the payment of the labourers. It is essential that payment of wages is made on time and that each labourer has a clear understanding for which period he is being paid. Delayed payments not only reflect bad organisation but will cause dissatisfaction among the workers, who very soon will lose the motivation to work.

It need hardly be emphasised that this is disastrous for any programme which depends on its labour as the main means of production.

When the casual employment system is used an additional problem has to be overcome. Under this system, workers are only paid for the days actually worked so that no fixed monthly wages are paid. This implies that payrolls cannot be prepared in advance but only after it is known how many days each individual labourer has worked. Since time will be required to prepare, check and process the payrolls and to obtain the money, this normally means that workers will have to be paid in arrears. For example, in the Kenyan Rural Access Roads Programme, payment is made on the 30th of the month but covers only the period up to the 16th from the 16th of the previous month.

Alternatively, a system of deductions can be used. In this case the workers are assumed to be present continuously so that the payroll can be prepared in advance. Deductions are made if individuals have been absent for one or more days. Whilst this system allows payments in full, including all days worked, it has several disadvantages. First, the work of the paying officer is substantially increased as deductions have to be made on the spot and the amount deducted has to be returned and accounted for. Secondly, the administrative work of the supervisor is increased as he will have to prepare deduction sheets. Finally, there is greater scope for fraud by both the paying officer and the supervisor.

Whatever the system used it should be such that:
(a) payment can be made on time;
(b) administrative procedures are simple;
(c) cross-checks can be made;
(d) a minimum number of departments/people are involved.

These points are inter-related but they basically mean that the payment system should be as simple as possible while allowing the necessary security against fraud.
The case study below illustrates that there are payment systems which have none of these characteristics.

6.1 CASE STUDY:

Finance and administration in the Honduras Rural Road Programme[*]

Labour-based techniques were not much used in Honduras before the start of the programme and, as in many countries, nobody really believed in their success. The budget for the first years was very small. It was easy to convince the engineers of the Ministry of Transport; the work was being done satisfactorily by hand. But we could not convince other

[*] Based on "Implementation Work in Honduras", by Norbert E. Kliver, in *The Study of Labour and Capital Substitution in Civil Engineering Construction* (World Bank, Sep. 1978)

ministries, such as the Ministry of Finance, to provide more funds and support. Indeed, it is still difficult every year to get even the small budget provided by the Ministry of Transport, because one of the first cuts made by the Ministry of Finance is on the labour-based construction programme. The Ministry of Finance still does not appreciate the problems for a labour-based construction site if wages are late.

Wage procedures

The current wage procedures illustrate the difficulties one faces. To get a job on the programme, workers must present the following personal documents:

1. Identity card.
2. Municipality tax record. Since poor people may not have paid any taxes for years, they cannot get the record without settling their tax obligations for the past three years. Taxes are not high but the people are so poor they cannot pay. So they try to find someone with influence who will guarantee that they will pay the taxes with their first wage.
3. Income tax liberation proof. If they have a cash income of less than the limit they do not pay taxes. But to get proof they must ask for a certificate from the Ministry of Finance and pay $0.25 for a form and a tax stamp. Since many labourers do not know how to write or how to fill out the form, the Department does it for them and pays for the tax stamps.

To get their wages, every month the workers must present these three documents.

When the muster roll has been typed in the department officer, five different stamps and signatures are needed in the Ministry. One letter missing in one name (for instance Robert instead of Roberto) is enough to get the muster roll rejected. Since it is not permitted to correct anything on a typed page, the whole page must be typed again.

Greater difficulties start when the muster roll is processed in the Ministry of Finance. Wage payment is made by special staff of this Ministry and only pressure personally exerted can persuade them that they should go to the site on time.

The situation became extremely difficult after January 1978 when workers started to be paid by cheques of the Honduran Central Bank. This meant that every worker had to go to town to cash his cheque, or that the site engineer had to cash it for him. But about 25 per cent of the workers do not know how to sign. Therefore the engineer needed a certificate, signed by two witnesses, that the person cannot write and that he authorises the engineer to cash his cheque. The project staff did consider transporting the workers to town with project trucks. But such an exercise would cost about $300 per site per month for the project budget. Since there are 12 ongoing sites, that meant monthly cost of $3,600, or the wages for 2,880 man-days. When workers go individually to the bank they lose about 30 per cent of their monthly cash income because of time off and transport costs. The project is therefore trying to get a revolving fund big enough to pay the workers every month. If the attempt is successful, this fund would be administered by the Department.

Labour laws

This labour-based programme is the first time the Honduran Government has employed many unskilled labourers. Consequently, no laws cover these new circumstances. The prevailing laws are designed to protect the labourers against

abuse by contractors. Consequently, except for a few supervisors or foremen, all workers must work with the Department until a project is finished. When a road is finished, the relationship between workers and Department is finished too. But the prevailing laws say that if a labourer has worked for more than two months before he is dismissed, he should receive one month's pay. To avoid these payments the Department could change the whole labour force every two months and lose all the benefits of skill and experience. Or it could interrupt the activities every two months for at least three days, or it could be in almost constant attendance at the labour court. This is what is actually happening, and the "General Manager of the Labour-Based Road Construction Company" is a regular customer of the court. So far he has been able to convince the different judges since they have a lot of understanding for the special position the project is in. However, the time he loses is considerable and, with the opening of new sites, the situation is not likely to improve.

Discussion

Concerning the case study the following questions can be posed to participants:

1. What was wrong with the payment system described in the case study?
2. How do you suggest this system be improved?
3. Do you envisage problems with your country's labour laws if large groups of casual workers are employed for longer periods; If so, which steps should be taken to overcome these problems?
4. Can yon foresee any problems with the existing payment system if you were the employer of .500 casual labourers who should be paid different wages on a specific payday? How would you ensure timely payment?

The faults of this payment system are not difficult to analyse; the project was used as a system to collect non-paid taxes; people who were not at all interested in the well-being of the project were responsible for the processing of payrolls and the payment of wages; moreover, cheque payments are not at all suitable for payment of large numbers of sometimes illiterate workers.

As regards the labour laws, it is clear that for a big programme of this type better preparation is required. The difficulties which the project manager attempted to solve on an ad hoc basis could have been foreseen before the programme was initiated. A special exemption should have been made in advance for this type of government-executed programme to prevent unnecessary conflicts with the labour legislation.

At this point it is interesting to discuss the participants' experiences with payment. Questions 3 and 4 relate directly to the systems in use, but it is worth while to try and analyse which steps have to be taken in their country to ensure timely payment of large numbers of casual workers. In many countries even the payment of the permanent staff (whose payrolls can be prepared well in advance since they have fixed monthly wages) is irregular and the causes of this irregularity are often not difficult to trace. If time permits, the participants can be requested to design a payment system suited to the situation described in question 4.

7 TRAINING

It is evident that the efficient implementation of labour-based road construction and maintenance requires well-designed planning, programming and organisational systems. In fact, since it is probably more difficult to handle large numbers of labourers than a small number of machines, there is all the more reason that the management of the labour-based type of construction should not be haphazard. However, for some reason this always seems to be the case. We have already seen above that labour-based programaes are often initiated without too much preparatory work; objectives are ill-defined, payment systems are not well designed, labour legislation is not adapted, handtools and light equipment (which we will discuss later) are often not of the right type, procurement systems are inflexible and, last but certainly not least, supervisory personnel are not properly trained to handle this "new" type of construction work.

It is easy to recognise that in labour-based programmes the role of the middle-level supervisory staff is crucial. These persons have to handle labour forces of up to 100 men who will definitely not achieve an optimum productivity if their work is not properly planned, set out and organised. Furthermore, the supervisor will be responsible for the administration of the labour force as well as the timely procurement and administration of handtools and construction materials for his site.

Once these points are made it may be worth while to discuss the following questions with the workshop participants.

- Do you think that special training is necessary for supervisory staff for labour-based road construction and maintenance?
- If so:
  (a) Which subjects should be included in the course syllabus?
  (b) How long would you recommend such a course to last and what percentage should be practical site work?
  (c) Should there be courses for different types/levels of supervisory staff? Which types/levels?

After the reactions have been noted on a blackboard or flipchart, ILO's work in this area can be mentioned. A "Guide for trainers of supervisory personnel for labour-based road construction" is under preparation and copies will be available in May/June 1981. While this Guide is mainly based on the training material developed for the Kenyan Rural Access Roads Programme, it is generalised to be suitable for use in other countries.

The Guide is in four parts. Part I describes the information required, the aspects to be considered and problems to be avoided in the planning of a course for supervisors. Part II serves as an introduction and guide to Part III and provides information on how the trainer should develop "country-specific" training materials not dealt with in Part III. It points out, by referring to experience elsewhere, what should be included in this "country-specific" training material. Part III consists of 15 training "modules", each dealing with a particular aspect of road construction. These modules, which are subdivided into a number of "learning elements", contain material which is generally

applicable in rural road construction. The even-numbered pages on the right-hand side of Part III contain the text for the trainees, while on the left-hand side, opposite to the corresponding trainees text, suggestions are made to the trainer on how to present the training material.

Part IV is a checklist of points to, remember. These "field instructions" will serve as a reference book for the supervisor when he is out on site.

The layout of the Guide is as shown below.

PART I - SETTING UP OF TRAINING COURSES

- Survey of existing training schemes
- Sources for recruitment of trainees
- Planning (a) Project requirements
- Integration with existing schemes
- Output requirements
- Necessary input
- Implementation (a) Fecruitment
- (b) Language
- Theory and practical training
- Follow-up of the training
- Checklist for trainers

PART II - THE MODULAR SYSTEM AND ITS APPLICATION

How to develop country-specific modules

PART III - TRAINING MODULAR

1. The programme
2. Planning
3. Reporting and control
4. Setting up and administration of a site
5. Work organisation
6. Tools and equipment .
7. Surveying and setting out
8. Site clearance
9. Earthworks
10. Drainage
11. Soil mechanics
12. Concrete technology
13. Structures
14. Gravelling
15. Maintenance

PART IV - FIELD INSTRUCTIONS

Checklist for trainees and basis for field training

Guide to employee performance appraisal

Performance factors	Far exceeds job requirement	Exceeds job requirement	Meets job requirement	Needs some improvement	Does not meet minimum requirement
Quality	Leaps tall buildings with a single bound	Must take running start to leap over tall buildings	Can only leap over a short building	Crashes into buildings when attempting to jump over them	Cannot recognise buildings at all let alone jump over them
Speed	Is faster than a speeding bullet	Is as fast as a speeding bullet	Note quite as fast as a speeding bullet	Would you believe a slow bullet?	Wounds himself with bullets trying to shoot a gun

It is important that the training continues on the job after training courses have been completed. Engineers should train their supervisory staff, who in tarn should try to transfer some of their knowledge to gangleaders and workers. There should be a constant communication between the site and the training school in order to improve the training course contents and methodology.

Also performance assessment of individual supervisors should be made at regular intervals. Such assessments or reports can serve as background documentation when promotion of supervisors is considered. The supervisors should be aware of this procedure, which will definitely have a positive influence on their motivation.

The format (though certainly not the content) of a performance assessment is shown below.

8 HAND TOOLS

Although handtools and light equipment such as wheel-barrows are the major means of production in labour-based road construction, their importance is usually underestimated. This is probably a consequence of the fact that in "normal" equipment-intensive projects they are not an important factor influencing productivity and can therefore safely be ignored.

However, it has become increasingly clear that the use of traditional (agricultural) tools in road construction adversely affects the productivity of labour. This is because their average life is short and because these tools are not suited to the different requirements of road construction work. It is definitely true that the use of improved tools and equipment results in greater productivity, increased tool life, and safer working conditions.

The essential requirements of efficient tools and equipment are that they:

- perform effectively the function for which they are intended;
- are strong and durable enough to have an acceptable working life, bearing in mind the "normal abuse" to which they will be subjected;
- be correctly proportioned to the body dimensions of the operator;
- match the strength and working capacity of the operator;
- should not cause premature fatigue;
- be safe in use;
- have initial and maintenance costs as low as possible.

While conditions vary from country to country, in general existing tools and equipment do not meet most of these requirements. Studies have shown that an important reason for this situation is the purchasing of tools and equipment on the basis of minimum price rather than to an agreed technical specification. Also very little knowledge exists on what would be the ideal handtool specifications for various types of construction work.

The task below briefly summarises this situation and can be used to analyse the existing procurement procedures and to determine whether the participants are aware of the importance of well-designed good-quality handtools.

8.1 TASK: Tools and light equipment

Handtools and light equipment are the most important means of production in labour-based road construction. Contrary to capital-intensive construction works where machines are used for the most important activities (earth-moving, spreading, shaping) all these activities in labour-based construction are done with simple tools.
It is easily understood, therefore, that general output .and productivity depend to a great extent on:

(i) whether the right tool/implement is chosen for the job;
(ii) the design and quality of these tools/implements.

For example, tool handles that break after only a short period of use would have a similar effect on labour-based productivity as a broken caterpillar track of a bulldozer

would have on that machine's productivity. Using hoes in places where mattocks or pickaxes should be applied would be comparable to excavating material with a grader.

However, judging from the types and quality of the tools commonly used all over the world, this point usually appears to be totally missed or, at best, not properly valued; handles for tools are usually cut straight out of the bush; hoe blades break after hitting a stone only once; eyes of tool heads are so badly manufactured that it is impossible to properly fit in a handle, etc.

In addition to the fact that the buyer is usually not very conversant with the type and quality he can and should insist upon, the situation is in many cases aggravated by the fact that the organisations responsible for the procurement of tools and equipment tend to opt for the cheapest item on the market, using the motto “a hoe is a hoe and a hoe costing ten shillings should be preferred to a hoe costing eleven”.

Question 1
Can you outline how an order for 1,000 hoes and 1,000 hoe handles goes through the system in your country? Indicate also approximately how long a period is required for each step.

Question 2
Estimate roughly the yearly requirement of tools for a road construction unit employing 300 labourers constructing and gravelling approximately 30 kilometres of road per year.

NOTE: After identifying the types of tools you need, try to estimate and agree as a group on their approximate average lifetime to arrive at the numbers required on a yearly basis.

Question 3
Please described how, if you were in charge of a labour-based road construction programme employing 300 labourers, you would obtain the required quantities of the right type of tools of the requisite quality and design and how you would ensure that you would have these tools in your possession one month before the start of construction work.

In case you have had personal experience with bad-quality tools, indicate which steps you took to overcome this problem and how effective these steps were.

Discussion

Approximate figures for the numbers of the most important handtools required per year for a construction unit employing 300 labourers are:

	Initial number	Life (months)	Required per year
Shovel	200	6	400
Bushknife	50	4	150
Hoe	200	6	400
Forked hoe	125	6	250
Mattock	75	12	75
Axe	25	8	37
Pickaxe	75	12	75
Pake/spreader	50	6	100
Sledgehammer	25	24	13
Wheelbarrow	50	6	100

Naturally, these figures are only approximate since the average life of the tool will vary with the quality. They do illustrate however the quantities involved for only a small number of labourers and the influence of quality/life on the yearly requirements.

If slides are available it is useful to emphasise the point by showing poor and good quality tools before and after a period of use.

An issue that is likely to come up at this time is how will inexperienced people be able to judge tool quality and design and specify their requirements.

To provide answers to these questions the ILO has published a “Guide to Tools and Equipment for Labour-Based Road Construction”. This Guide not only catalogues the tools and equipment available for civil construction works but also provides advice on their design, manufacture, application, use, testing and maintenance.

The purpose of this Guide is to assist those responsible for the planning and management of labour-based road construction to provide the most suitable tools and equipment for the execution of the work. It does this by presenting information which will allow the reader to:

- specify efficient tools and equipment;
- establish acceptance-testing procedures for such implements;
- advise local manufacturers on the production of good quality tools and equipment;
- contact sources of supply of good quality implements;
- ensure that tools are used and maintained correctly.

One of the major principles of the Guide is that tools and equipment should always be purchased on the basis of technical specifications appropriate to intensive use on construction activities:

- The Guide contains advice on specifications for handtools and methods of testing ranging from simple visual checks to destructive techniques.
- In many countries, the present situation could be improved by simply importing better tools and equipment, but this would produce only short-term gains. More permanent benefits will result from local manufacture of improved tools and

equipment. Therefore, the emphasis in the Guide is on local improvements through better design and manufacture:

- The Guide contains advice on the design and manufacturing techniques for simple handtools using, where possible, local materials.
- There is a range of implements not in current use, largely because they are unknown to the responsible authorities, which could improve the output and safety of labour in road construction:
- The Guide contains advice on tools and equipment that might usefully be introduced on labour-based projects with, where possible, sufficient information for their local manufacture.
- The full benefits of improved tools and equipment will only be obtained if correct working methods are used:
- The Guide includes advice on correct tool usage and maintenance.

Examples of handtools and simple construction equipment available from manufacturers in developing and developed countries are included. The purpose is to illustrate the possibilities for improvement and innovation by imparting more appropriate technology rather than to provide a comprehensive catalogue of sources. Since the Guide is aimed specifically at road construction, it is divided into sections which broadly follow the sequence of operations required to construct a road. At the beginning of each of these sections, there is a list of the tools and equipment that can be used for the operation described, followed by a brief discussion of the factors governing the choice of which tools to use for a particular activity.

The tools and equipment are described under five headings: (i) design, (ii) material, (iii) manufacture, (iv) operation and (v) suppliers. In the case of “general purpose” handtools, i.e. handtools which can be used for more than one road construction operation/activity, only their design, material, manufacture and suppliers are described in a general section. Their “application” and “operation” are described in the relevant sections.

The information given in each section is that required to obtain an appreciation of the characteristics of each tool or item of equipment. More detailed technical information is given in a number of Technical Notes. These notes give information on steel and wood properties and treatment, testing, maintenance, sources of power and handtool weights in relation to the strength and size of its operator.

Most of the tools and equipment are illustrated. The information given covers significant points of design, the materials required for the manufacture of efficient implements and desirable methods of manufacture.

Where appropriate, information is given on sources which can provide the item under consideration to appropriate national and international specifications.

To illustrate the work it would be useful to have a sample of this Guide to pass around. It can be mentioned that a limited number of copies are available upon request and can be obtained from the Technology and Employment Branch, ILO, Geneva.

9 MAINTENANCE

It is an unfortunate fact that the existing road network of many developing countries is in a poor condition and rapidly becoming worse. This is mainly due to lack of adequate routine maintenance. Road maintenance is generally accorded low priority both by engineers and by government planners. Consequently, the recurrent budget allocated to road maintenance is usually far from sufficient. This means that, with the available resources, it is impossible even for efficient road maintenance organisations to keep all roads under their responsibility in a reasonable condition.

The situation becomes more difficult every passing year as (a) the recurrent budgets available for road maintenance are in most cases not even keeping up with inflation, and (b) the. number of kilometres under the responsibility of the various maintenance departments is constantly increasing. This means of course that the effective amount available for routine maintenance per kilometre of road is decreasing.

Table 5 illustrates the situation in Tanzania by depicting the total recurrent allocations available for the maintenance of secondary and tertiary roads from 1973 to 1977.

Table 5: Expenditure on secondary and tertiary roads
(TSh million)

	1973/74	**1974/75**	**1975/76**	**1976/77**
Recurrent	53.4	70.8	57.7	53.9

Table 6 shows that Tanzania is not an isolated case but that in many other developing countries maintenance budgets are insufficient to cover the costs of adequate maintenance.

The situation is aggravated by the fact that maintenance is usually carried out using sophisticated machinery which, having *been* supplied by external donors, is often difficult to maintain and repair. It need hardly be mentioned that the running costs of such machinery have risen sharply in the past six years due to rapidly increasing prices of energy. This development had a direct effect on the prices of oil derivatives but was also felt indirectly by its effects on the cost of spare parts and their transport to the site.

Table 6: Road maintenance Statistics

Country	Km of paved and gravel road	Road density km/100 sg km	Km/1000 head of population	Average maintenance expenditure/km $	Estimated average maintenance cost $
Benin	3 351	6.4	2.9	400	935
Bolivia	8 000	3.5	7.1	260	
Botswana	1 450	2.0	23.0	220	
Burundi	550	11.0	2.3	242	900
Cameroon	9 300	6.0	4.7	450	800
CAE	7 790	1.7		180	
Honduras	4 500	7.0	2.0	887	1 630
Guinea	6 000	5.4	2.5	170	950
Ecuador	10 000	8.3	3.3	436	1 000
Guatemala	8 800	13.0	2.7	650	950
Lesotho	1 380	11.5	2.9	490	
Mali	3 310	1.0	2.4	260	700
Mauritania	1 560	1.0	5.6	230	
Nepal	1 730	3.1		450	900
Paraguay	1 450		2.6	400	
Senegal	5 850	6.7	3.4	530	
Sudan	4 500	0.7	1.0	50	2 000[1]
Swaziland	1 700[1]	16.3	5.3	460	
Togo	2 400	13.0	3.2		950
Upper Volta	3 700	6.0	2.9	230	
Malawi	1 340	11.0	2.2	222	
Tanzania	9 000[2]	5.0	3.0	470[3]	1 100[3]
Zambia	11 900	4.5	7.0	430	

[1] *For paved roads.* [2] *Estimate.* [3] *Trunk roads only.*

Discussion

To get an indication of the maintenance situation in the regions for which the participants are responsible, the following questions can be discussed. The best results will be obtained if the participants are requested to reply in advance to the questions on an individual basis as an evening study task.

1. How many kilometres of road is your region responsible for maintaining?
2. What is the recurrent budget for road maintenance in your area/region?
3. In the last year, how many kilometres of road have been newly constructed in your area/region?
4. How much money was available in the last financial year for the construction of new roads or major rehabilitation works (separate from the recurrent budget) in your area/region?
5. What is the total number (including unserviceable) pieces of equipment available in your region? Separate into dozers, graders and front end loaders.

6. How many machines in each of these categories are presently in working condition? All machines currently being repaired should be excluded.

The responses to the last two questions are likely illustrate that in many government agencies the availability of equipment is low. The large numbers of broken-down pieces of equipment which can invariably be spotted at public works ministries' yards provide sufficient evidence that this is the case in many developing countries.

The total amounts of recurrent maintenance funds and. development (new construction) funds for the whole of Tanzania are shown in table 7 (1977/78). The table also shows the significance of these figures in terms of available maintenance funds per kilometre of road and numbers of kilometres which can be constructed with the available development funds.

Table 7: Recurrent and development budget for roads in Tanzania

	Trunk roads (9 320 km)	**Secondary and tertiary roads (35 700 km)**
Recurrent maintenance allocation	$14 million	$10.6 million
Maintenance allocation per km	$1 500/km	$300/km
Development allocation	$15.4 million	$9.4 million
Kms of new construction	69 km[1]	470 km[2]

[1] Assumes construction cost of $225 000 per km.

[2] Assumes construction cost of $ 20 000 per km.

Table 8 shows the way these roads are represented in various categories. It is worth noting that of the 28,000 km of regional and district roads only about 9,000 are in a maintainable condition and will require major rehabilitation. This again is a situation commonly encountered in many developing countries.

Table 8: Kilometres of road in Tanzania

	Trunk roads	**Local main roads**	**Regional and district roads**
Bitumen surface	2 660	360	-
Gravel/earth	6 660	7 330	28 000[1]
Total	9 320	7 690	28 000[1]

[1] Only 9 000 in a maintainable condition.

Whilst this data is applicable to Tanzania, it is likely that the road maintenance situation in other African countries will have common characteristics.

9.1 TASK: Road maintenance planning

Given that (i) the funds available for maintenance will not increase a great deal, (ii) the costs of personnel and equipment are steadily increasing; what steps would you take to ensure that the maximum number of kilometres of roads can be kept in a passable condition?

Discussion

To emphasise the problem it is advisable to discuss this question in the context of rural roads. Although most governments attach great value to rural development and recognise the importance of an efficient rural road network, invariably rural roads are the first to be neglected when maintenance funds are limited.

At this stage, for the information of the participants, it should be pointed out that the rural road maintenance system developed in Kenya, employing individual "contractors" on sections of road, has proved quite effective and cheap. Naturally, it is not necessary to adopt this Kenyan system without modifications. It is possible to modify this system to fit different political and social structures. For example, groups of people or villages may be contracted to carry out maintenance on a "payment by result" basis. *Of* course, it would be necessary in such cases to clearly define the duties and responsibilities of everyone involved if the new system is to be successful.

Summarising the objective of this exercise, the participants should attempt to identify all possible ways to organise and carry out maintenance with an emphasis on involving local people to a greater extent than usual, rather than only concentrating on making the existing system work better.

The Tanzanian regional and district engineers participating in the Arusha Workshop offered the following approach:

Step 1. Identify sections of road network which are in a maintainable condition, i.e. which do not need major reconstruction before routine maintenance can be started.

Step 2. Identify those sections of the road network which require priority reconstruction.

Step 3. Determine which maintenance methods can be used for the sections of road to be maintained and establish costs per kilometre for each alternative.

Step 4. Compare the demand for reconstruction and maintenance with the supply of funds and other resources. Do not improve/reconstruct roads if no resources are available to maintain them.

Step 5. Allocate available funds to reconstruction and maintenance of specific sections of road. Concentrate on those sections which would make the road impassable during the rainy seasons.

Step 6. Follow up with regular control to ensure that the different maintenance methodologies are operating efficiently.

This approach differs from the usual practices in two important ways. Firstly, it recommends the use of various methods of maintenance, e.g. to make villages responsible for the maintenance of stretches of road and to pay them a fixed amount

after a fixed period for work properly carried out. This system is a variation of the system developed in Kenya where, as mentioned, an individual contracts system has been successfully tried out. In Kenya this system proved to be far cheaper per kilometre than the traditional maintenance methods which make use of labour camps and sophisticated machinery.

Of course, each category of road will require a particular type and level of maintenance, depending on variables like traffic density and type of soil. On highly trafficked roads which are prone to corrugation some kind of grading will always be necessary. Here as well, however, alternative methods such as tractor-drawn drags may prove to be quite economical for certain traffic densities. Also, in any case, there is no doubt that an open-minded engineer can design a large number of alternatives to make his money stretch further:

The second difference of the Tanzanian approach is the focusing of reconstruction / maintenance on road sections, i.e. to practice selective upgrading / maintenance with the objective to keep a larger number of kilometres passable on a year-round basis.

Although these recommendations as such are sensible and will - if carried out properly - undoubtedly keep a maximum number of kilometres in a passable condition, a number of problems will have to be overcome if this strategy is to be successful.

Examples of the types of problems likely to be encountered are the following. Presently, in many public works ministries, engineers tend to use routine maintenance funds for emergency works and for upgrading of sections of road washed away after heavy rains. By doing so on an ad hoc basis crises are effectively dealt with as they come up but advance planning of maintenance and reconstruction becomes virtually impossible. Funds originally allocated for routine maintenance and intended to cover a full year period usually run out before this period is finished. The inevitable result is that part of the road network will not receive its due share of routine maintenance. For various reasons this part usually tends to be the minor rural roads network of the region.

In addition, administrative and organisational difficulties are likely to be encountered when different types of maintenance systems are run concurrently and operated by the same organisation. Control and reporting for village or individual contract systems will differ from the practices employed for permanent maintenance staff. If a payment-by- result system is adopted, this will have to be organised in such a way that payments can be made timely to those individuals or villages who have produced the required results. It will also be necessary to develop a quality control system to enable the maintenance supervisor to judge objectively whether the quality of the work justifies payment.

Furthermore, different and additional planning will be necessary. If selective maintenance is practised, it should be clear which sections of road are maintained by which methods. Also the frequency with which different types of roads will be graded, dragged or brushed should be clearly established.

Obviously, it will be necessary to thoroughly analyse the existing maintenance systems in a particular country before recommendations can be made as to which approach should be taken and what changes will be required.

If, however, as was the case in Tanzania, the workshop participants themselves come up with suggestions of this nature, it is worth while to try and analyse the prevailing situation and to develop a strategy to overcome the institutional and organisational problems associated with the new approach.

9.2 TASK: Road maintenance organisation

Depending on the response obtained during the earlier session on maintenance, some or all of the following questions may be discussed:

- How are funds for road maintenance allocated? Start at central level and determine who has the final financial' responsibilities in the regions/districts.
- Define the general principle of the system; are funds allocated on the basis of a fixed yearly amount per kilometre of road of a certain category; as quarterly allocations per region/district; as yearly allocations for different classes of road; as a yearly lump sum covering maintenance of all roads in a certain area?
- How easy is it to reallocate funds intended for a particular purpose to other purposes? Is it possible, for example, to finance emergency maintenance works on a major road in the area from funds allocated for routine maintenance of minor roads?
- Is equipment utilised full time throughout the year or does it have to be stopped occasionally when funds run out? If so, which period of the year is affected most?
- Would it, in principle, be possible that funds, originally allocated for routine maintenance in one area, are withdrawn during an ongoing maintenance period to finance emergency works in another area?
- How would you plan routine maintenance of selected stretches of road using more than one maintenance system?
- How would you organise the maintenance organisation in your area to ensure that your plans (as outlined above) can be carried out effectively? Would you, for example, reorganise the existing maintenance supervision system; would it be necessary to use the existing transport differently; would you need more (or different types of) transport; are links with the government administration necessary; what role would you like this administration to play?
- A good way to answer these questions would be to draw up an organisational structure chart with a short explanation of the roles of the different persons/groups within this structure. This explanation should include a short description of the means at the disposal of these persons/groups (transport, labour, camps, materials, tools, etc.)
- If your proposals were approved, what changes in the allocation of funds system can you foresee to be required to allow their effective implementation?

10 CONSOLIDATION

Before starting work on the final task, which deals with various aspects of implementing a labour-based road construction programme, a slide presentation on the Rural Access Roads Programme is useful to illustrate the Kenyan approach.

The ILO has prepared such a presentation highlighting the most important aspects of the programme and showing how the construction is carried out. Also the organisational and administrative structure of the programme is illustrated.

This opportunity could be taken to discuss issues such as selection of roads, supervisory training, recruitment procedures, maintenance organisation in more detail as required. There is no doubt that the Kenyan experience can be of use elsewhere, although adaptations to different social and political circumstances may be necessary. The administrative systems and working methods developed by the programme are, however, mostly of general applicability and certainly deserve to be studied.

10.1 TASK: Planning a labour-based proqramme

The Government has decided that, in your region, 400 kilometres of rural access roads will be (re) constructed. Labour-based methods will be used. It has been found out that labour supply from people living along the roads will not be a problem. Sufficient funds have been allocated. It has been stipulated that the construction should be completed within two years. The roads to be (re) constructed have been selected. The programme includes 20 different roads of an average length of 20 kilometres.

Your task consists of four elements: planning, administration, supervision and maintenance.

(a) Planning

(i) Describe the growth of the programme in terms of:

- the number of kilometres (re) constructed per three months considering that on average 50 km will have to be built every quarter to finish the reconstruction within the stipulated two-year period.

Note: Make a graph with the cumulative number of kilometres reconstructed on the vertical axis and, on the horizontal axis, the eight quarters of the two years.

- The number of supervisors required in each quarter.

(ii) How would you go about establishing task rates for the most important activities.

(b) Administration

(i) Tools

Given that six months before the start of the programme the government stores only contain a limited number of handtools and these tools are of inferior quality and design:

- which steps would you take to ensure that six months later you have 6,000 handtools (different types) of a good quality and design in your possession?

(ii) Payment

- Describe how your 1,500 casual labourers will be paid. Use the following model:

Who	**When**	**What**
(Person responsible for action)	(Day of month)	(Short description of action to be taken)

Your solution should start with the registration of workers, describe when and by whom the muster-rolls are collected, when and by whom payrolls are prepared, who checks and authorises them, and when and by whom the payment activities are carried out. Include all steps to be taken finishing with the actual payment on site.

(c) Supervision

(i) Given that you will need approximately 20 supervisors to control the works, from which sources would you recruit them?

(ii) What kind of date should your supervisors collect to enable you to monitor and control the projects? Think of personnel administration, construction progress, tools and equipment etc.

(d) Maintenence

(i) After the programme has terminated you will have to maintain 400 km of rural roads in addition to the roads already under your responsibility. How much do you estimate the yearly cost of maintaining these roads to be? How and when would you forewarn the responsible authorities that these funds are required?

(ii) Indicate which steps you will take to ensure that the roads receive regular maintenance immediately after construction and on a continuous basis thereafter.

Discussion

The purpose of this task is to tie together what the participants have learned during the workshop and to assist them to apply this knowledge afterwards.

The task focuses on the planning, administration, supervision and maintenance of a 400 km road project to be carried out with labour-based methods.

It is advisable to hand out this task on the evening before it will be discussed and to request the participants to individually work out their approach. The following day a number of groups (consisting of four to five participants) should be formed. Each group should formulate a joint approach to overcome each of the various problems.

In a plenary session, spokesmen will voice the agreed opinion of their respective groups. The discussion leader will attempt to formulate an integrated plan of action, incorporating all the group contributions. At the same time he should try to identify the institution/agency/individual responsible for taking the initiative necessary for the project to be effectively carried out.

Finally, a time schedule for the various activities should be prepared. The objective of this exercise is to give all participants a clear idea of what is involved to set up and execute a labour-based project and of their own role within such a project. This is also an opportune time to clarify the respective roles of the Government, external donors and the ILO, especially as to how the latter two could assist in setting up projects concerned with the efficient application of labour-based methods.

11 WORKSHOP EVALUATION

It is good practice to have the participants appraise the workshop proceedings and structure. The following is a questionnaire designed for that purpose.

The questionnaire
Please give us your reactions to this workshop to help us design better ones in the future.

1. Arrangements
The arrangements for your stay here were:

satisfactory …….. unsatisfactory ……..……..

2. Organisation

2.1 A good workshop should have the right mix of classroom listening (passive learning) and work by the participants (active learning). What do you think about the proportion of active and passive learning at this workshop?

	need less	about right	need more
lectures	……...	……	……
discusssions	……..	……	……
individual tasks	……..	……	……
group tasks	……..	……	……

How could this mix be improved in the future?

……...

……...

……...

2.2 What about the length of the workshop?

Should have been shorter …… longer ……

was about the right length ……

2.3 Can you suggest improvements in the group discussions and individual tasks?

……...

……...

2.4 How could the group discussions have been better organised?

……...

……...

……...

3. Learning, skills and attitudes

A good workshop should give you an opportunity to review your own experience and to learn by comparison with others.

3.1 Did this workshop assist you to:

(a) assess the most appropriate methods for rural road construction and maintenance?

not at all …….. in some ways …….. very much …….

Comments: ……

……...

(b) plan the implementation of road construction and maintenance activities?

not at all …….. in some ways …….. very much …….

Comments: ……

……...

(c) more effectively organise the work on site?

not at all …….. in some ways …….. very much …….

Comments: ……

……...

3.2 Do you now feel that labour-based methods of road construction:

(a) are of no practical value in your country? ……..

(b) should only be used when no equipment is available? ……

……...

(c) should be used when their cost is comparable to the cost of using machines? ……...

Comments: ……

……...

4. Future arrangements

4.1 What type of follow-up activities should be taken to promote the use of labour-based methods in your country?

……...

……...

……...

……...

……..

4.2 A workshop is, in the end, only of real use if what has been learned can be applied. What do you see as the major problems in using what you have learned?

(a) lack of government support/interest …….

(b) attitude of workers ……..

(c) technical problems (cost, quality, speed) ……...

(d) administrative procedures …….

(e) lack of money ……..

(f) other …….

……...

Name ……

TECHNOLOGY AND EMPLOYMENT PROGPAMME

Publications on appropriates construction technology

1. A.S. Bhalla
   Technological choice in construction in two Asian countries: China and India, *World Development*, Oxford, Mar. 1974.
2. R. Ericksson, A. Yllö and N. Lundgren
   WP.3 Thai workers in heavy road construction activities. An ergonomic pilot study, Apr. 1974.
3. G.A. Edmonds
   ILO seeks new approach to construction of roads in developing countries, *New Civil Engineer*, London, 26 Sep. 1974.
4. G.A. Edmonds
   WP.13 The role of design in the choice of road construction techniques, Feb. 1975.
5. Moise Allal
   WP.14 Selection of road projects and the identification of the appropriate road construction technology: general considerations, Feb. 1975.
6. G.A. Edmonds
   WP.15 A framework for data collection on road construction, Mar. 1975.
7. ILO/IBPD: A field manual for the collection of productivity data from civil construction projects, Technical Memorandum No.8, July 1975.

*****8. G.W. Irvin, et al.
Roads and redistribution - Social costs and benefits of labour-intensive road construction in Iran, ILO, Geneva, 1975, Sw.Frs. 25.

9. M.T. Hussain
   Labour-intensive construction of irrigation works, Aug. 1976.
10. Ministry of Works/ILO/NORAD
    Implementation of appropriate road construction technology in Kenya, Geneva, Nov. 1976.

*****11. W. A. McCleary in collaboration with Moise Allal and Bertil Nilsson *Equipment versus employment. A social cost-benefit analysis of alternative techniques of feeder road construction in Thailand,* ILO, Geneva, 1976, Sw. Frs. 25.

12. Report of ILO/SIDA/ADB Seminar on the Application of Appropriate Technology in Road Construction and Maintenance, 16-26 May 1917, Manila. Part I: Summary of Proceedings: Part II: Technical Papers (limited copies only available).
13. M. Allal, G.A. Edmonds and M.I. Hussain
    The development and promotion of appropriate road construction technology, *International Labour Review*, Vol. 116, No.2, Geneva, Sep.-Oct. 1977.
14. J. Capt and G.A. Edmonds
    WP.33 Study of small contractors in Kenya, Geneva, Dec. 1977.

*15. M. Allal and G.A. Edmonds in collaboration with A.S. *Bhalla Manual on the planning of labour-intensive road construction*, ILC, Geneva, 1977, Sw.Frs. 40.

16. ILO: Study on the use of labour-intensive methods for the Indus Super Highway in Pakistan. A report prepared by the ILO for the Government of Pakistan, Geneva, 1977.
17. ILO: Roads and Resources: an evaluation of the factors affecting the application of appropriate technology in road construction, Geneva, Jan. 1978.
18. G.A. Edmonds
    Manpower - Horsepower: making the best of both words, *New Civil Engineer,* London, 6 Apr. 1978.
19. ILO: The Kenya Rural Access Roads Programme: report of the joint donors review and evaluation, Geneva, June 1978.

*20. Deepak Lal, et al.
Men or Machines: a Philippines case study of labour-capital substitution in road construction, ILC, Geneva, 1978, Sw.Frs. 25.
21. J.D.G.F. Howe and I. Barwell
WP.40 Equipment for labour-based road construction, Geneva, Nov. 1978.
22. M.I. Hussain
WP.4l Application and upgrading of indigenous technology: the case of irrigation works, Geneva, Nov. 1978.
23. I. Barwell and J.D.G.F. Howe
Appropriate transport facilities for the rural sector of developing countries. Prepared jointly for ILO/UNIDO, Geneva. Jan. 1979.
24. Bernd Balkenhol
WP.48 Small contractors: untapped potential or economic impediment? Some observations on the construction industry in Cameroon, Niger and Sierra Leone, Geneva, Apr. 1979.
25. G.A. Edmonds
The construction industry in developing countries, *International Labour Review*, Vol. 118, No. 3, Geneva, May-June 1979.
26. ILC: Kenyan Rural Access Roads Programme: Report of the joint donors review and evaluation, Geneva, June 1979.
27. David Birch and J.R. Rydzewski
WP.57 Energy options for low-lift irrigation pumps in developing countries - the case of Bangladesh and Egypt, Geneva, Apr. 1980.
*28. J.J. de Veen
The Rural Access Roads Programme: appropriate technology in Kenya, ILO, Geneva, 1980, Sw.Frs. 20.
29. G.A. Edmonds
Labour-based road maintenance: policies and prospects. Paper presented at the PTRC seminar on Highway Design and Maintenance in Developing Countries, London, 1980.
*30. G.A. Edmonds and J.D.G.F. Howe
Roads and Resources: appropriate technology in road construction in developing countries. Intermediate Technology Publications. London, 1980.
31. Asit K. Biswas
WP. 63 Labour-based technology for large irrigation works: problems and prospects, Geneva, Aug. 1980.
32. M.I. Hussain
Indigenous resources and water supply management, *Water Supply and Management*, Vol. 4, pp. 201-219, Pergamon Press Ltd., UK, 1980.
33. M.H. Amer
WP. 68 Technology for construction and maintenance of irrigation and drainage works in Egypt: a preliminary assessment, Geneva, Sep. 1980.
34. Abul Khair, Sunil Ch. Dutta and M. Ataur Rahman
WP.69 Development and application of indigenous low-cost technology to minimise water losses due to seepage in irrigation canals: the case of Bangladesh, Geneva, Oct. 1980.
35. M.I. Hussain
Appropriate construction and maintenance technology for irrigation and drainage works in developing countries. Paper prepared for the International Commission on Irrigation and Drainage, New Delhi, Oct. 1980.
*36. ILO

* Priced publications, available from ILO (Sales Department), CH-1211 Geneva 22, Switzerland, unless otherwise indicated.

Guide to tools and equipment for labour-based road construction, Geneva, 1980, Sw.Frs. 60.

37. G.A. Edmonds
WP.70 Institutional aspects of the construction industry in developing countries, Geneva, Nov. 1980.

38. G. Ofori
WP.73 The construction industry in Ghana, Geneva, Oct. 1980.

39. G.A. Edmonds
Small change for small contractors, *NCE International,* Oct. 1980.

40. ILO: The Kenya Rural Access Roads Programme - Report of the joint donors review and evaluation, Geneva, Nov. 1980.