REPUBLIC OF KENYA

MINISTRY OF TRANSPORT AND COMMUNICATIONS

ROADS AND AERODROMES DEPARTMENT

MINOR ROADS PROGRAMME
INTERIM
TECHNICAL MANUAL

APRIL 1987

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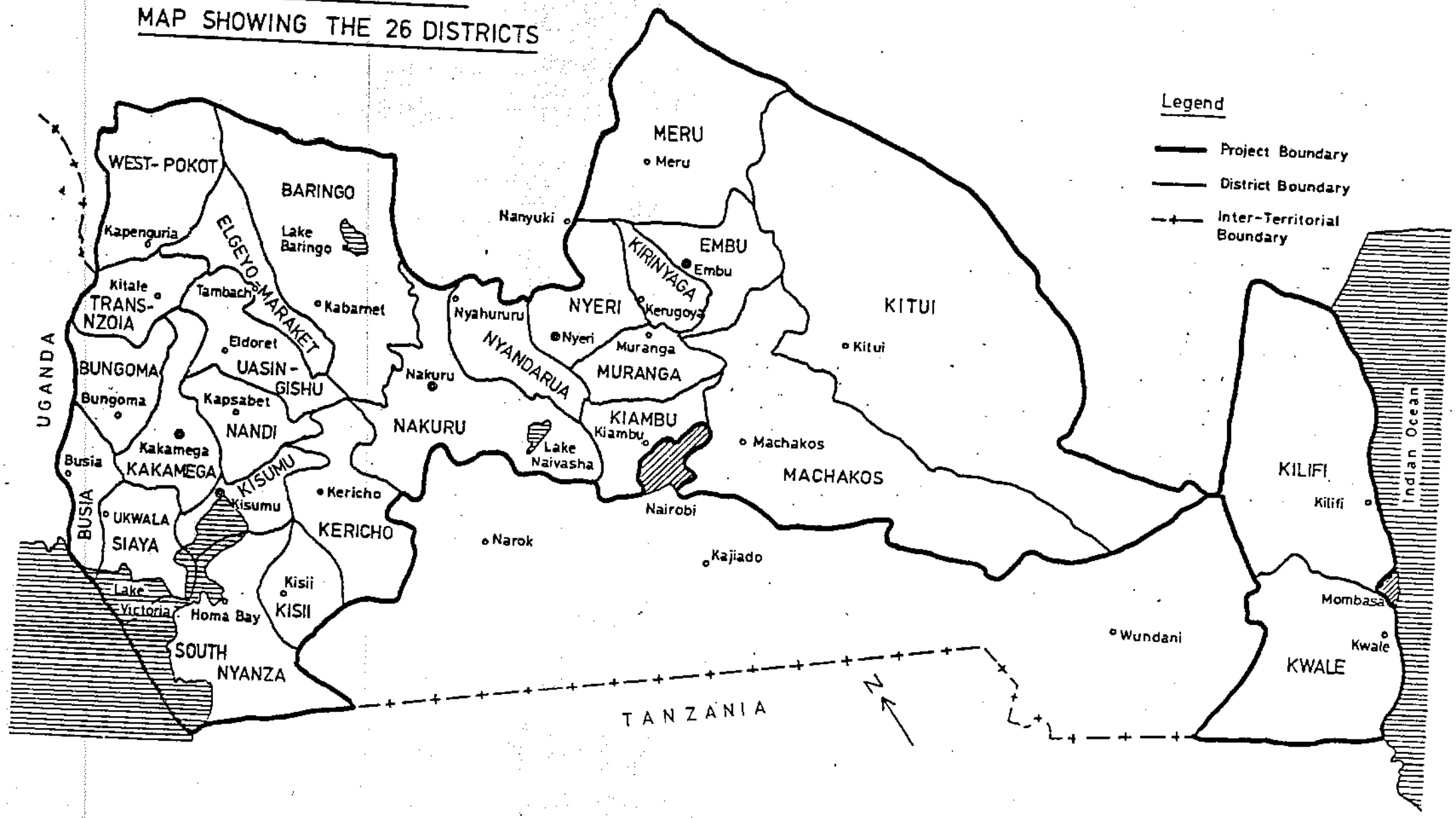
MINOR ROADS PROGRAMME

MAP SHOWING THE 26 DISTRICTS



F O R W A R D

This manual is an interim issue to be used for the initial implementation of the Minor Roads Programme (MRP).

In due course a more comprehensive and detailed manual will be issued. It will be updated from time to time as techniques and systems developed by the Technology Unit will be finalised.

The manual is intended as a handbook for MRP Engineers.

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MINOR ROADS PROGRAMME

TECHNICAL MANUAL

CHAPTER 1.0 : MRP MANAGEMENT AND ORGANIZATION

1:1 Introduction:

The Minor Roads Programme will be organized and managed at three levels; namely the Headquarters, Regional and District.

1:2 HEADQUARTERS ORGANIZATION

The organization at Headquarters will be responsible for overall co-ordination, planning and monitoring of the Programme. Some of the specific and important responsibilities for the Headquarters Organization will include.

(a) Liaison with other Government Ministries which essentially includes Finance, Planning and National Development and Agriculture in order to ensure a high level of co-operation among those involved in rural road infrastructure.

(b) Liaison with the representative of donor agencies in matters related to all technical assistance.

(c) Co-ordination of resource allocation including trained manpower, equipment and funds among the field units in order to meet the requirements of the approved work Programmes.

(d) Liaison with Department of Staff Training in order to ensure sufficiency of trained manpower for the implementation of the Programme.

(e) Procurement of equipment and handtools.

See Charts I and 2 for the Mininstry and MRP organisation.

1.3 REGIONAL ORGANIZATION

The Programme is expected to be divided into four administrative regions in order to ensure closer supervision of the Programme at district level. These regions are:-

a) Western Region: Will comprise of Nyanza and Western Provinces Programme districts.

b) Rift V. Region: Will comprise of the Rift Valley Province Programme districts.

c) Central Region: Will comprise of the Central Province Programme districts.

d) Eastern Region: Will comprise of Eastern and Coast Provinces Programme districts.

Each Region will be supervised by a Regional Co-ordinator Their specific and important responsibilities will include:-

a) To co-ordinate in his region the formulation of annual improvement and maintenance Programmes and submit the same to the Headquarters for approval.

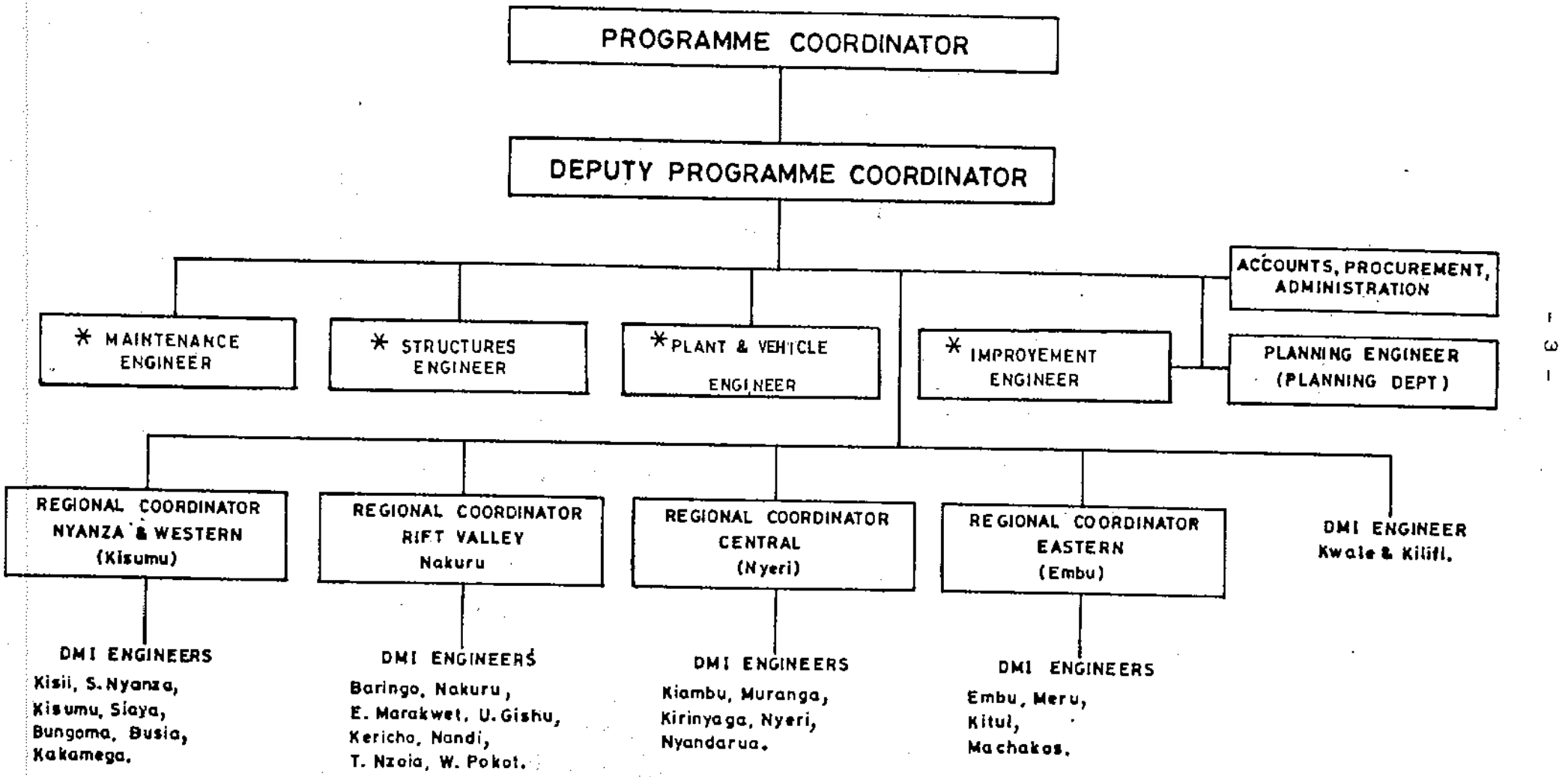
b) To define resource requirements in terms of trained manpower, equipment and funds to implement an approved work Programme.

c) To allocate resources among the district units in his region.

d) To supervise and guide the improvement supervisors in the execution of the approved work Programmes.

CHART I

PROPOSED MR/RAR PROGRAMME ORGANISATION STRUCTURE

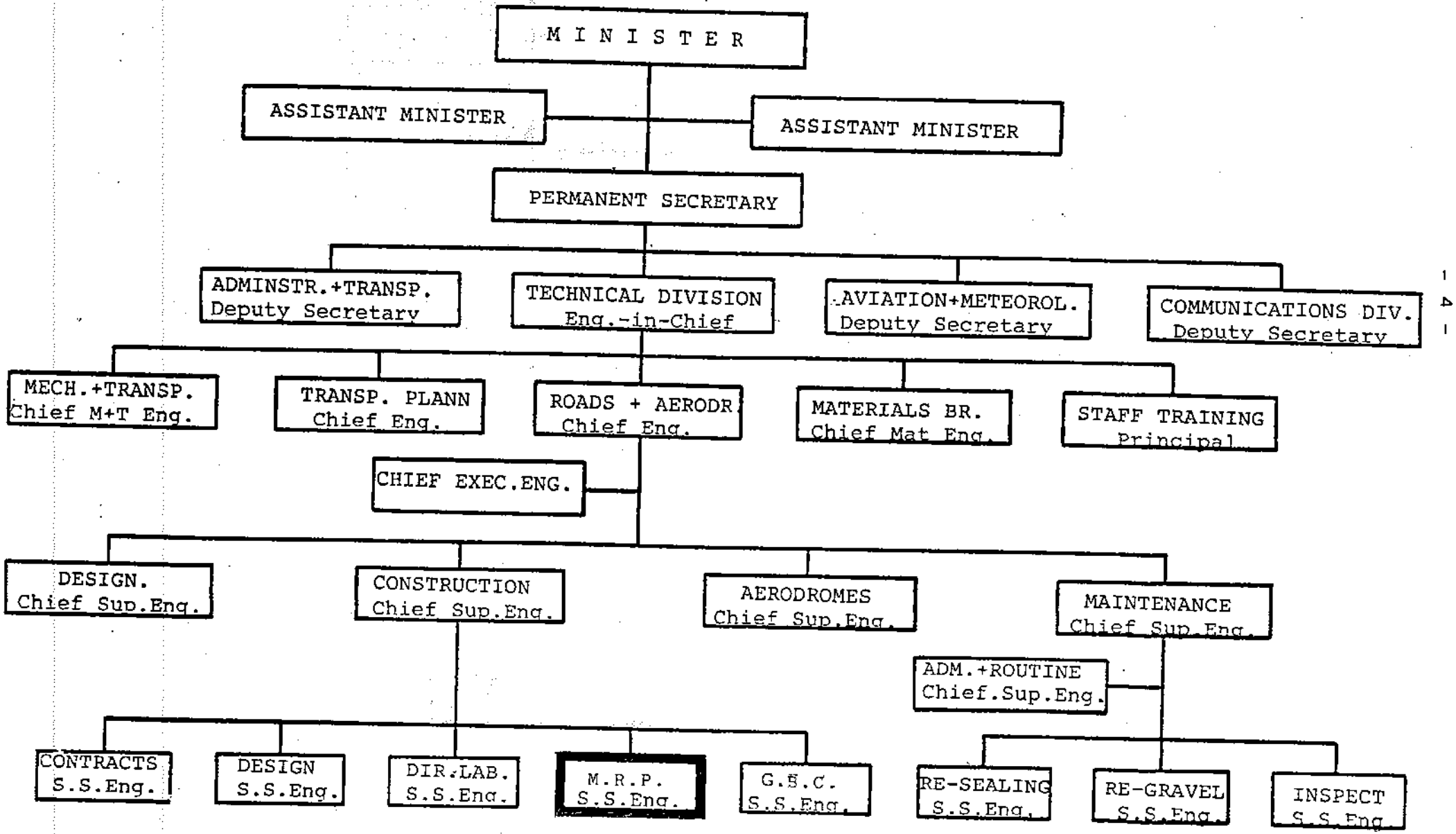


*: SUGGESTED INPUTS TO TECHNOLOGY UNIT AS NECESSARY

CHART 2

MINISTRY OF TRANSPORT AND COMMUNICATIONS

ROADS DEPARTMENT



e) To inspect and approve all roads on completion of improvement to earth standard and again gravelling and at each stage sign a Certificate indicating that the road has been constructed to the required standard or to direct the corrective measures as needed.

f) To inspect the condition of the road under maintenance and direct corrective action as needed.

g) To implement standard work reporting systems and ensure reporting accuracy so that performance of district level can be evaluated on a regional and Programme-wide basis.

1.4 DISTRICT ORGANIZATION

1.4.1 Introduction

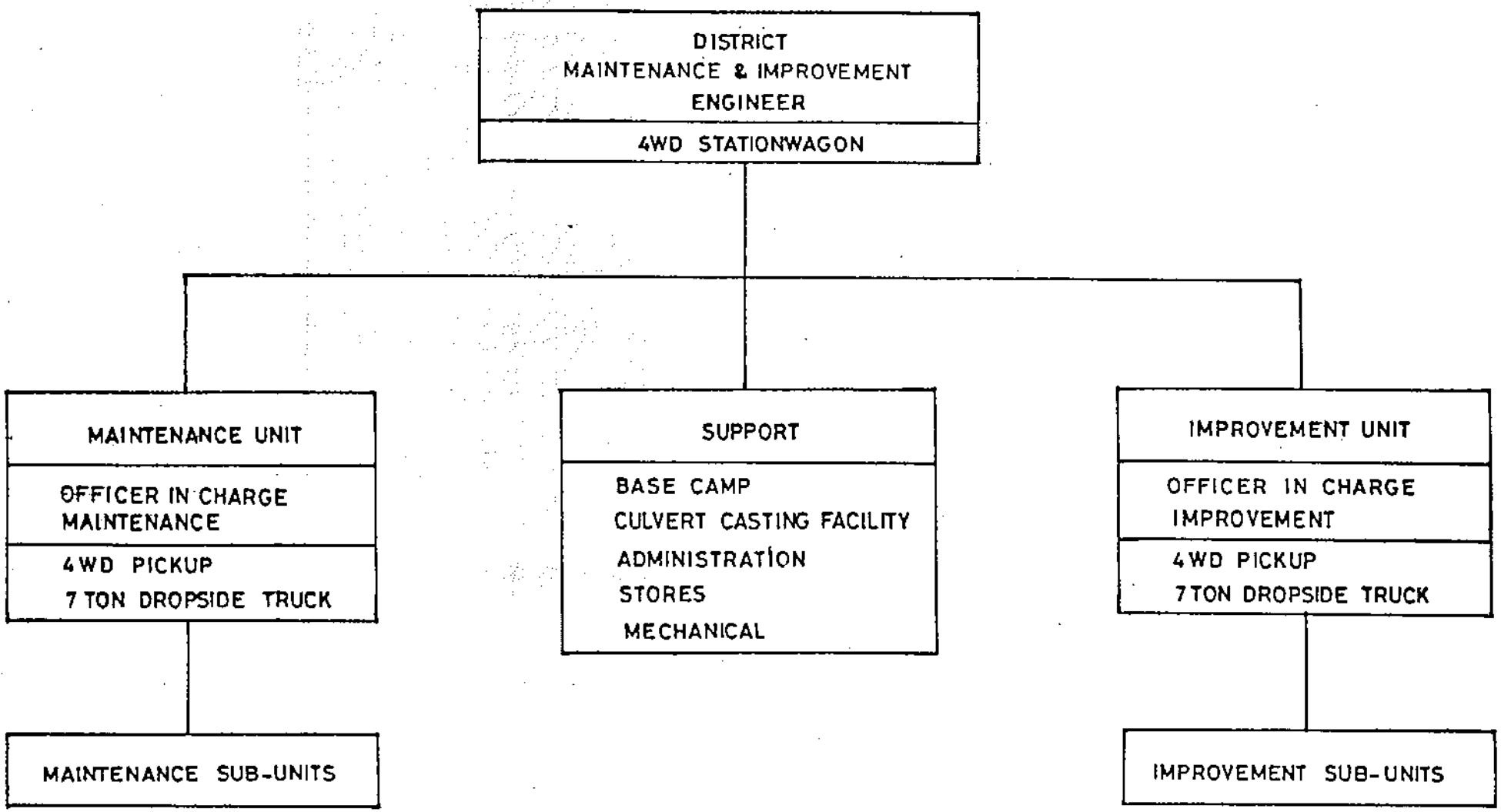
The district organization will be headed by a district improvement supervisor who will be usually an Engineer. He will be responsible for the implementation of an agreed improvement works Programme of one (1) or two (2) improvement units in a district. He will also be responsible for the labour-intensive maintenance of all the rural access roads and the roads to be improved under MRP in the district. The proposed MRP unit organization will thus be charged with the responsibilities for labour-based improvement and maintenance of the roads in the district.

Charts 3, 4 and 5 show the MRP District Organization.

The Maintenance Organization is described in Chapter 7.

CHART 3

PROPOSED MR / RÁR PROGRAMME DISTRICT ORGANISATION

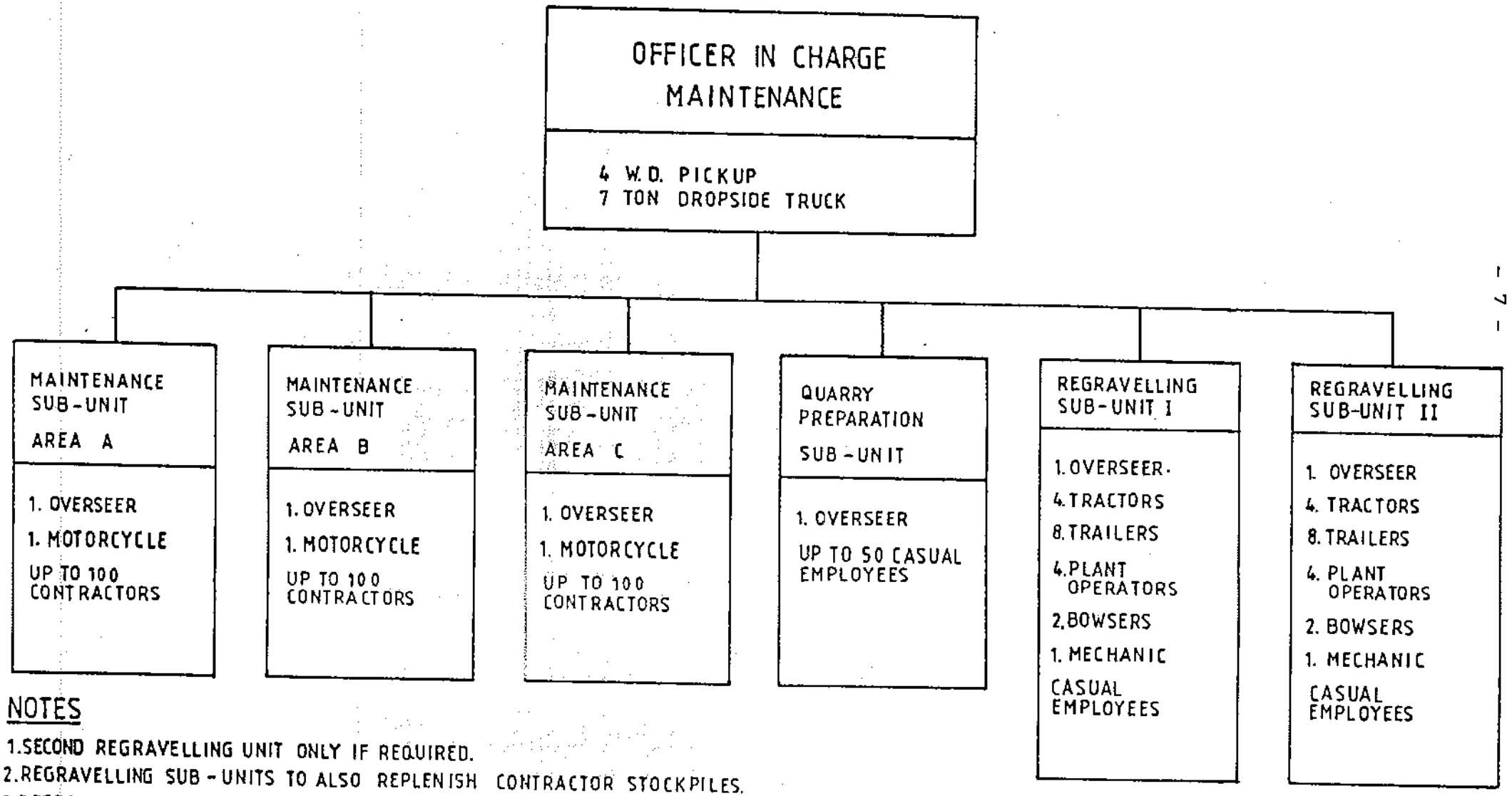


NOTES.

1. In some districts additional improvement units will be required

CHART 4

PROPOSED MR/RAR PROGRAMME DISTRICT MAINTENANCE UNIT

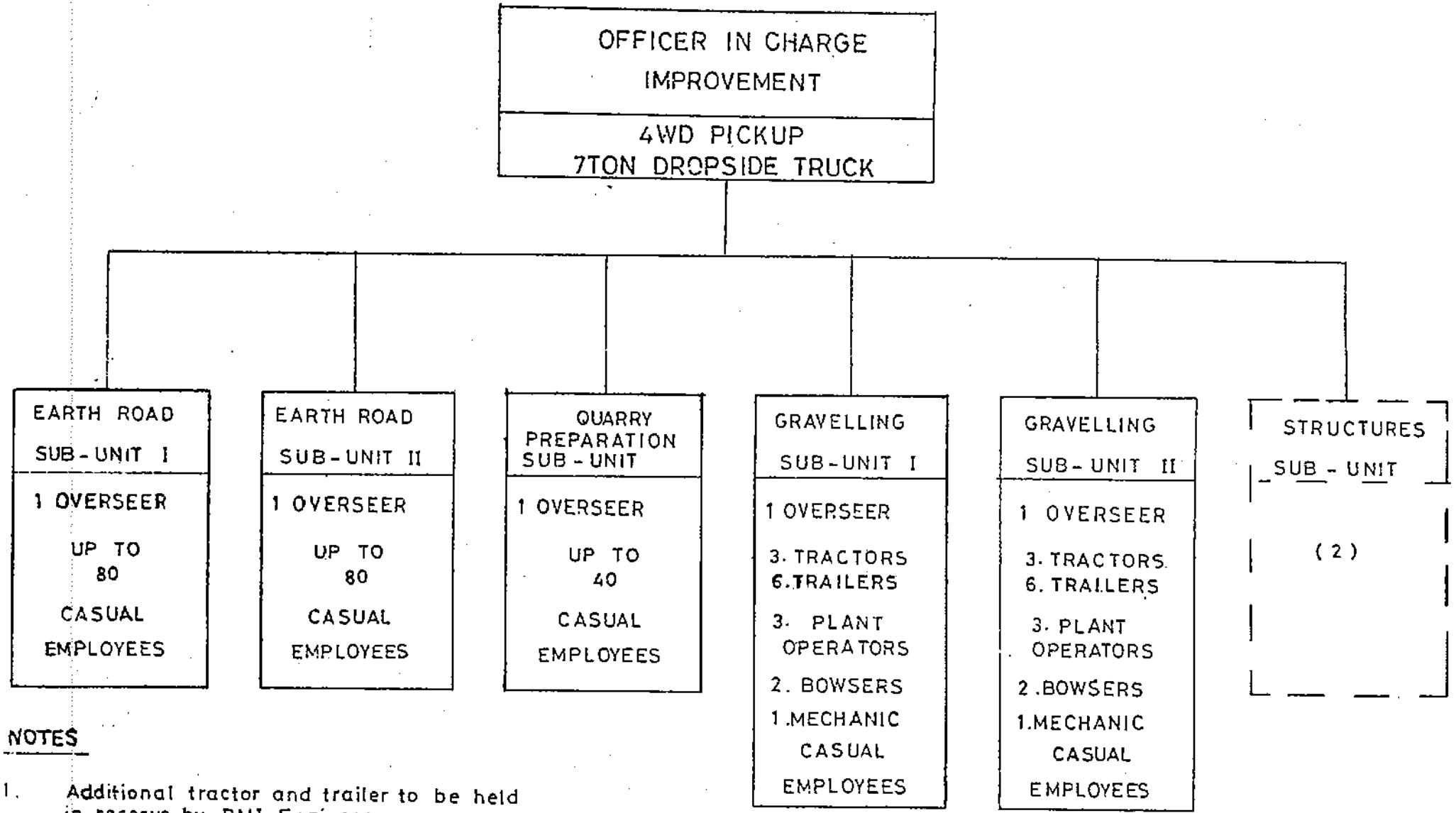


NOTES

1. SECOND REGRAVELLING UNIT ONLY IF REQUIRED.
2. REGRAVELLING SUB-UNITS TO ALSO REPLENISH CONTRACTOR STOCKPILES.
3. REGRAVELLING RESOURCES CALCULATED ON 7500 cu m OF REGRAVELLING/STOCKPILING PER UNIT YEAR.

CHART 5

PROPOSED MR/RAR PROGRAMME DISTRICT IMPROVEMENT UNIT



NOTES

1. Additional tractor and trailer to be held in reserve by DMI Engineer.

2. Structures sub-unit to be deployed as necessary with engineering and skilled personnel resources mainly from Provincial Engineers Bridge Unit

1.4.2 Level of responsibility

The MRP District Maintenance and Improvement Engineer (DMIE) shall have the total responsibility for the supervison of both MRP construction(improvement) and maintenance. All his instructions both technical and **administrative will be given** to his assistants preferably in writing.

Under the engineer, there shall be Officers-in-charge who will usually be of the rank of Inspector Roads. They will deal with the day to day site problems through a number of road overseers. Their instructions to the overseers shall be in writing and in duplicate. While inspecting the improvement or maintenance works, the engineer shall at all times be accompanied by the relevant Officer-in-charge of the works.

1.4.3 Improvement Unit

Each MRP improvement unit will have two improvement sites, two gravelling sites, one yard for casting culvert rings and one structure **sites.** These sites will be termed sub-units and each will be the responsibility of one overseer. The culvert casting **yard,** store facilities, repair of tools and vehicles will be centralised at the base-camp in order to enhance close supervision.

Each MRP unit is expected to improve and gravel about 30 km per year and engage about 350 casual workers daily such that the number of them engaged per site is limited to no more than 80. This will help close supervision by the headmen and the overseer on site. A total of 29 MRP units are expected to be initiated in the previous RARP districts. RARP units will also continue for some time in Baringo and Nyandarua districts.

The Overseer shall be responsible for the daily running of a site with a number of headmen assisting him. Each headman will be in-charge of a gang of labourers not exceeding 25 people who will be performing one improvement activity or two if they are located quite close to one another. The headman shall be a casual worker who will be recruited from the labour-force because of his distinguished leadership. He shall be able to pass on and carry out instructions given to him by the overseer.

1.4.4. Site Organization

i) Introduction

A "Site" in MRP will mean one road section under improvement or gravelling. The objective of the site will be to improve the road to the specified standard as effectively as possible. The improvement works of the site will be supervised by one overseer assisted by a number of casual headmen. The following administrative duties must be carried out by the overseer:-

a) Muster roll calls
b) Keep daily site records
c) Compile monthly site records.

ii) Labour Force

Each improvement site shall have a daily casual labour force of about 75 people who will be expected to form three main gangs of upto 25 people. The headman shall be in-charge of a gang.

The size of the gangs will not vary with the length of the road, but will be limited to the number that overseer and headmen will be capable of effective supervison on each task.

The casual workers to be hired for NRP will be recruited from within the close locations of the roads. The casual workers will thus be local people.

The improvement of the roads is expected thus to bring benefits to those people living within their immediate proximity.

When the improvement of the road is completed and the improvement site moves to another location, the workers will be laid off. This policy has been established in order to spread the cash earnings from the temporary employment as widely as possible. It will also enable the Programme to avoid providing large labour-camps and transporting workers to the sites. In this way, the Programme will not incur expenses associated with the provision of transport for workers and large labour camps and their related social facilities. The money saved in this way will be used to hire even more casual workers and finally improve more kilometres of roads. The casual workers will thus be expected to walk daily from their homes to the improvement sites. Their wages will be calculated on daily basis and they will enjoy no additional social benefits.

The recruitment which will be carried out by the engineer and his Officer-in-charge will be done with the assitance of the local administration. The local Chief will be charged with the responsibility for spreading the word about the occurrence of employment and assisting the engineer in explaining to the workers the conditions of employment. The Chief and the DMIE should make it clear that both men and women are equally eligible for work on the programme.

If more workers than can be absorbed come forward for employment, the workers to be engaged will be seleected by 'lottery'. This is crucial in order to avoid charges of corruption and favourtism.

The lottery will be executed by lining and counting the number of applicants. Tickets equal to the number of applicants will be prepared with 'YES' and 'NO' inscriptions. The number of 'YES' tickets will represent the number of vacanicies available. Each applicant shall be asked to pick up one ticket from a container containing all the tickets.

The applicants who will pick up a 'YES' ticket will be asked to sign an employment formal form which will contain the conditons of employment. Enough people should be recruited to cover the requirements of labourers headmen, storemen, water carriers, watchmen and tool sharpener. The recruits should be advised on which days they will report for work. (not all will be required on the first day).

iii) Moti vation of the Casual Workers

For economy and success of a labour-based construction works, it is fundamental to keep a high labour productivity. To achieve this high productivity, it is necessary to introduce some management systems that provide incentive schemes for motivating the workers. Three basic schemes exist for labour payment in road construction. These are:-

a) Daily Paid whereby workers are paid an agreed upon sum of money each day in return for working a fixed number of hours.

b) Piecework whereby workers are paid an agreed upon sum of money per unit output. The daily output being left to the discretion of the worker.

c) Taskwork whereby workers are paid a fixed daily wage in return for a fixed quantity of work.

The dispersed nature of the MRP sites makes supervision of daily paid work difficult and the labourers are not motivated to produce good output. Although the piecework system would provide the greatest incentive to labour, it would not be suitable for use in MRP because it may disrupt the agricultural sector by attracting workers totally from it. There are also problems of management. This system would be suitable for migrant labour not also relying on their own subsistence agriculture. Since migrant labour will be discouraged from the Programme, the system cannot be used in MRP.

The task work system of payment is the one that will be adopted in the Programme, because beside realising high productivity rates, the local people will be free to go home after finishing their taskwork. The incentive in this case is not that that the workers can earn more money as they would with piecework, but they can utilize their spare time for doing other work in their homes such as farming. Wherever feasible the Programme will use taskrates in the execution of the improvement activities.

iv) **Prompt Payment of Wages**

Besides fixing a wage rate which will attract labour-force and is commensurate to production, the other most important motivation of the workers is to pay them correctly and on time. Hardly anything else lowers the morale of the workers as much as delayed pay.

To ensure that payment will be effected promptly, the Programme will pay the workers on monthly basis but about two weeks in arrears. The payment period will be from 16th of the previous month to the 15th of the current month. The period from 16th to the end of the current month will be used for the preparation of the payrolls and ensuring that payment will be arranged at the end of the month.

v) Site Camp

The road to be improved should be split into manageable sections of about 5 km length. Before improvement work is started, a site camp shall be erected. The location of the camp shall be decided by the engineer and shall preferably be halfway along the first road section. It shall be near a source of water and be accessible to MRP vehicles.

It shall consist of two main huts which will house the overseer and the store and two small ones which will be the toilet and the bathroom. The huts which will be made of corrugated iron sheets or steel panels shall be made in such a way that they are movable.

vi) Equipment and Tools

Almost all of the improvement works will be carried out by labour except the gravelling operation where a number of tractor trailer combinations will be used for haulage.

The equipment in the Programme per improvement unit is expected to be limited to the following:-

ITEM	QUANTITY	REMARKS
Landrover Station Wagon	1	for use by the DMI engineer (Improvement & Maintenance)
Landrover pick-up	1	for use by the Officer-in-charge. (Improvement)
60 HP Agricultural tractors and	7	) for gravelling operations.
$4m^3$ trailers	13	)
Truck	1	for carrying construction materials.
Water/fuel Bowsers	4	
Hand/Animal drawn rollers.	2	(For earth road sites)

Handtools are the means of production in a labour-based Programme. High quality handtools are therefore very important. The procurement/handtools for MRP will be /of centralised in order to ensure that only high quality handtools are procured.

The handtools required for an improvement site employing about 75 casual workers will be expected to be in the order of:-

	Number
Jembes	70
Fork jembes	30
Shovels	60
Mattocks	30
Pickaxes	30
Pangas	20
Slashers	20
Spreaders	20
Garden rakes	20
Axes	5
Sledge hammers	5
Mason hammers	5
Earth rammer	10
Flat files	10
Wheelbarrows	6
Claw hammers	2
Crow bars	4
Spirit levels	5
Tape measures 30m	2
Tape measures 15m	2
Ranging rods	2 sets
Bonning rods	1 set
Electric torch	2
Water buckets	8
Bushman saws	2
Mason towels	3
Great coats	2
Police whistles	2

Ditch+slope templates	3
Ditch templates	3
Ø 60 cm culvert templates	2
Grinding wheel	1
Anvil	1
Pair of bellows	1
Abney level	1
Marker pens	As required
Sisal twine	As required

The handtools shall be issued to the workers in the morning when they report for work and be collected and kept in the site store after work.

CHAPTER 2.0: DESIGN STANDARDS

2.1 Introduction

The Minor Roads Programme (MRP) will cover D, E, Special purpose and Government access roads only. The contents of this chapter are partly guidelines and recommendations to be considered and partly standards which as a general rule shall be adhered to. In some instances special conditions may demand modifications to these standards. (The Rural Access Road Standards are contained in Appendix I).

Not all the minor roads shall be improved under the Minor Roads Programme but they shall be selected as described in the evaluation report. The selected roads are not expected to be carrying high traffic because of their poor conditions. After improvement, the roads will be expected to allow for a speed of about 60 km per hour with an exception of some sections where the condition of the terrain will necessitate lower geometrical standards and consequently considerably lower speed. Unless where the improvement conditions of the road do not permit, the improvement of the minor roads will follow as much as possible the existing vertical and horizontal alignment. This will have the advantages of minimizing the earthwork and consequently reduce the overall cost of the roads. The minor roads will be improved to comply with MOTC's Road Design Manual Part I except where deviations are necessitated by the conditions of the road, and the desired standards for roads improved using labour-based methods.

2.2 Horizontal and Vertical Alignments

The aim of the Programme is to improve the roads at least cost and allow the passage of traffic in "all weather" To achieve this objective, it is essential that the roads

will be surfaced with appropriate material and be provided with adequate drainage which is capable of collecting and discharging surface water rapidly. The vertical and horizontal alignments of these roads will thus be applied in order to make the improved roads safe and compatible to "all weather" requirements. The roads will be improved to meet the following geometric design requirements:-

Particular	Flat and rolling terrain	Hilly terrain
Horizontal Curves		
Desirable min.	100m	50m
Gradients		
Desirable min.	2%	2%
Desirable max	8%	10%
Absolute max	10%	12%
Stopping Sight Distance		
Desirable min.	80m	80m
Absolute min.	40m	40m

The desirable minimum gradient is required for adequate drainage and the absolute gradient will be acceptable over a maximum length of 100m. Most vehicles would be unable to negociate steeper gradients when loaded.

In order to minimize the improvement cost, it is proposed to gravel only selected sections rather than the entire length of the improved roads. However, a gravel wearing course will have to be provided over those sections with weak in-situ soils or with longitudinal gradients exceeding 5 per cent. It is expected that a higher proportion of roads will be gravelled in high rainfall

areas than in low rainfall areas. On a Programme wide basis it is expected that about 50 - 75 per cent of the total length of roads improved will be gravelled. This figure will be finalised in due course.

Four types of cross-sections are proposed for use in MRP. In general, roads will be improved on their existing alignment and realignment will only be carried out where there is a strong technical justification. The basic cross-section will be the standard section for earth and gravel roads specified in the MOTC's design manual but adapted to suit labour-based maintenance.

The improved roads will have a carriageway of 5.4 m wide gravel wearing course on a 5.4m wide earth formation. The thickness of gravel wearing course will be 15cm when uncompacted (12 cm when compacted). The measurements of side ditches have been chosen in such a way that in the initial stage, a theoretical camber crossfall of 10% is expected. In practice the camber will be more rounded.

2.3 Drainage

The drainage system is the most important feature of the road and is made up of side drains, mitre drains, culverts, catch water drains and scour checks.

Mitre drains shall be constructed to lead water from the side-drains and from culverts. The size, distance and location of the mitre drains will depend on topography. The mitre drains shall be such that on steep slopes they shall be constructed very close to each other (20 m spacing if possible) and at longer distance on a gentle slope. This will minimize damage by scouring and flooding both to the road and the land on to which the water is led.

Catchwater drains shall be used wherever possible to cut off water from areas higher than the road before it reaches the side-drains and divert it, directly through a culvert.

Due to siltation and problems in cleaning culverts of smaller sizes, the smallest size of culvert to be used in MRP shall be 60cm diameter. The fill on top of the culvert, shall be about ⅔ of its diameter. If this cover is not maintained the pipes will likely be broken by the passage of trucks. The bed shall be well prepared, of good material and have gradient of 2 - 5%. The joints shall be covered with mortar. Culvert Head walls and aprons shall be built of masonary or of packed stone.

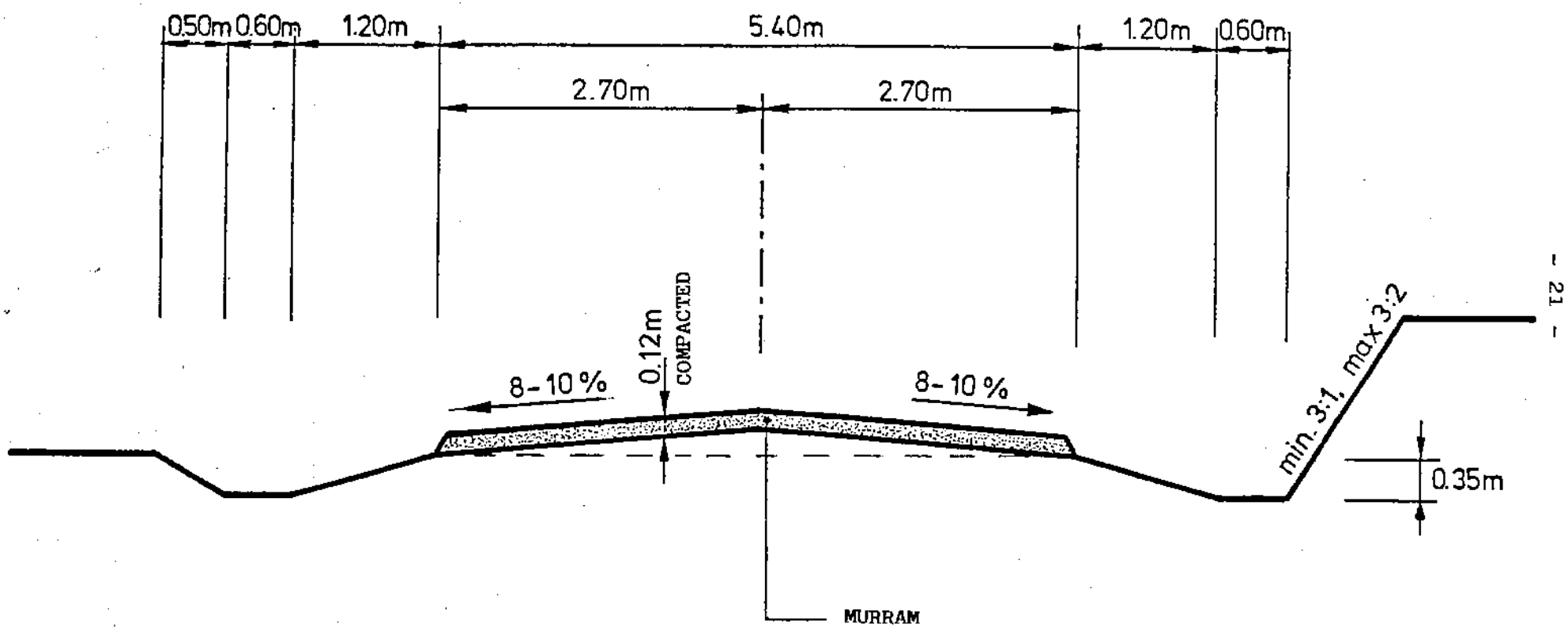
Side ditches will only perform as designed if the design cross-section is maintained i.e. excessive scour must be prevented. Thus for long lengths of side ditches at gradients in excess of 4-5%, scour checks shall be constructed such that no damaging scouring will occur. Scour checks will mainly be made of pieces of wood, packed stones, or loose stones mortared.

vi) Structures

The structures in minor roads improvement Programme shall be cross over culverts (discussed above), large or multiple culverts, drifts, box culverts and bridges upto 10 metres span. These structures are discussed in detail in Chapter 4.0.

CROSS-SECTION "A"

(STANDARD CROSS-SECTION)



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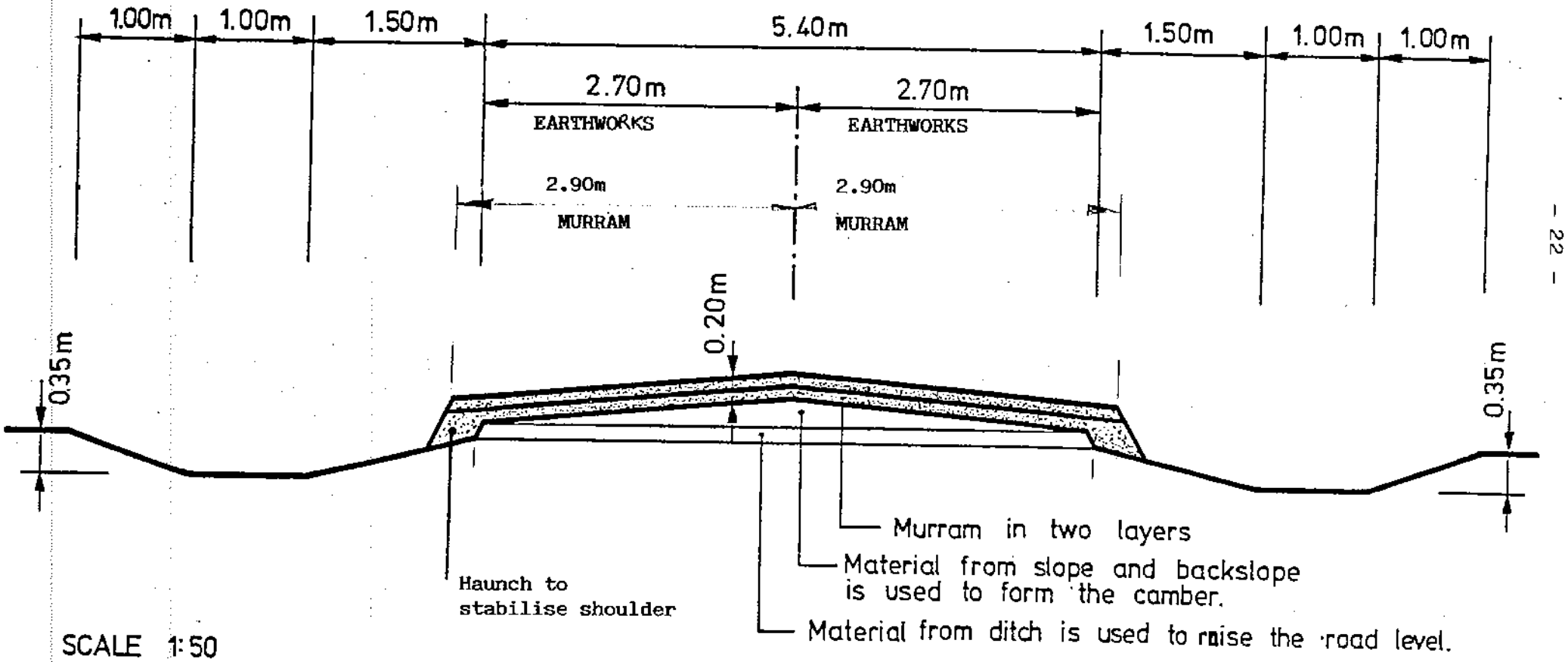
CROSS=SECTION "B"

(BLACK COTTON CROSS - SECTION)



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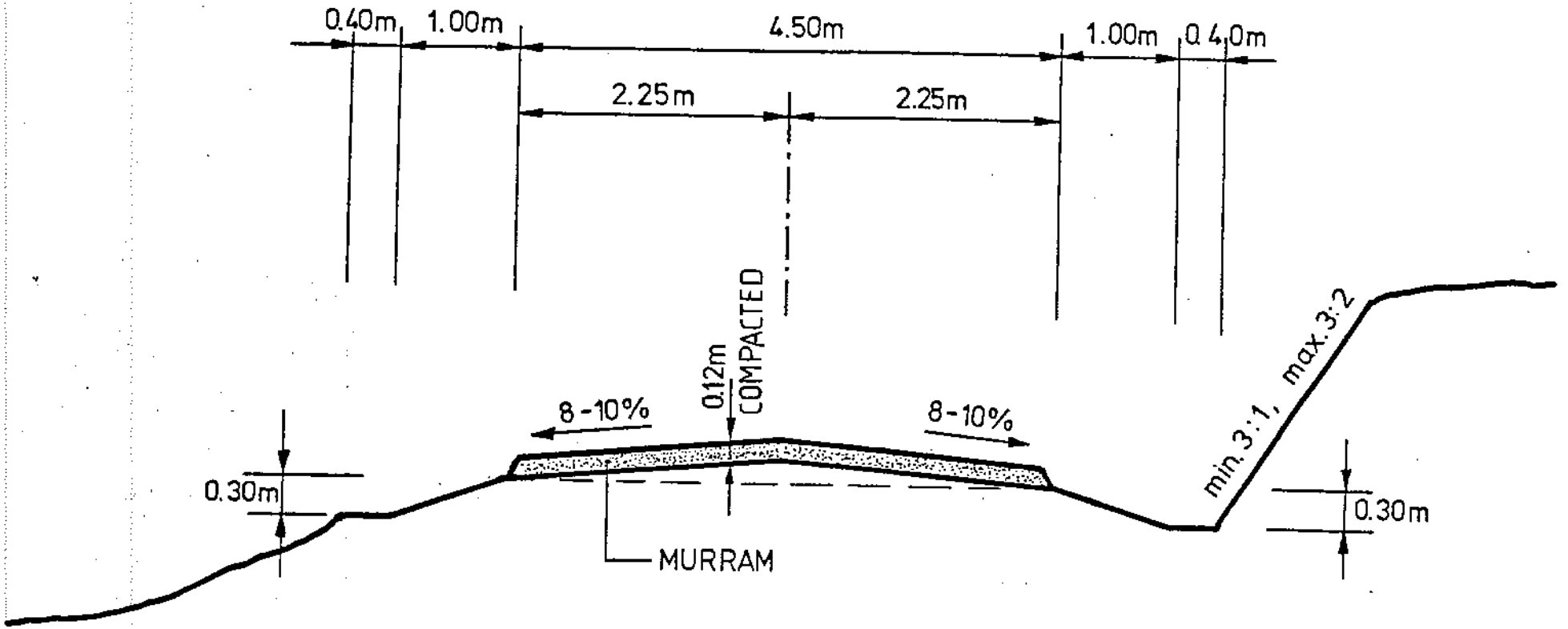
CROSS - SECTION "C"

(REDUCED CROSS - SECTION - SEVERE TERRAIN)



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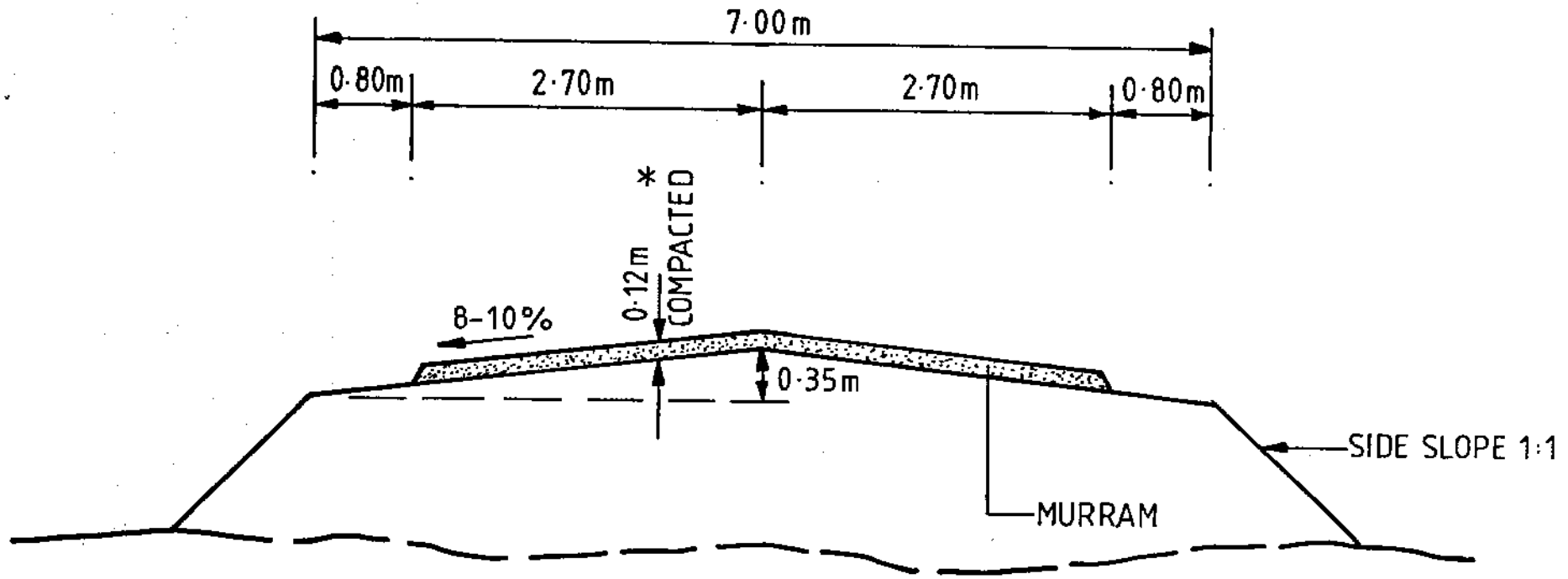
CROSS-SECTION 'D'

(EMBANKMENT CROSS - SECTION)



* 0·20m ON BLACK COTTON SOIL

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CHAPTER 3.0: IMPLEMENTATION FEATURES OF MRP

3.1. Introduction

The improvement of Minor Roads to all weather roads shall be carried out in two stages as follows:-

i) The construction of earth road with complete drainage system.

ii) The gravelling of earth roads which will be expected to start 3 to 6 months after completion of stage one above where the road is left to compact(settle) naturally. Where compaction by tractor /hand/ animal roller will be applied, then the gravelling work could start immediately after completion of the improvement works to earth formation. The earth road construction shall be done manually by casual labour while the gravelling will involve hauling material by tractor-trailer combination after excavating and loading it by hand.

Concrete culvert rings for the drainage system shall be cast at a central place preferably within the base camp in order to ensure close supervision by the Engineer.

In order to simplify supervision and enhance workmanship the process of road construction is broken into a number of simple activities which can readily be carried out by individual or group of labourers. The construction activities will therefore be executed in a sequence. At the beginning of each working day, the overseer will be expected to have programmed three activities which will be performed in that day. The following sequence of construction activities is recommended for adoption.

(A) **Road Construction**

a) Staking the alignment and acquisition
b) Bush clearing
c) Stripping topsoil and grubbing
d) Tree and stump removal
e) Boulder removal
f) Slotting - constructing control berms every 10 metres
g) Excavation and filling to level
h) First compaction
i) Excavation of catchwater drains
j) Formation of side drains (i) ditching + 2nd compaction
(ii) slopping and backslopping
k) Formation of camber
l) Final compaction
m) Installation of culverts
n) Excavation of mitre drains
o) Installation of scour checks

(B) **Gravelling**

a) Locate and acquire quarry
b) Strip overburden on quarry
c) Build an access road to quarry
d) Reshape the road to be gravelled (if necessary)
e) Excavation of gravel
f) Loading gravel
g) Hauling gravel
h) Spreading gravel
i) Compaction

3.2 Incentives in MRP

Taskwork has proved to be a good incentive and relatively simple to administer and control and will be used wherever possible.

"Task work" means that a daily wage is paid for a defined quantity (and quality) of work. When the work has been completed, the workers are free to leave the site.

For effectiveness, the tasks shall be correctly set since tasks which are too small give loss in productivity and tasks which are too large discourage the workers, and lower their work morale.

Correctly set tasks can only be achieved if the following criteria have been fulfilled.

1) The volume (quantity) of the work to be done must be correctly measured and computed.
2) The degree of difficulty (eg. soil type) has to be correctly assessed and the corresponding task-rates found.
3) The number of man-days (i.e. the number of men needed to finish the work in one day) must be correctly calculated.

The following activities will be given on task-work basis:-

Topsoil removal
Slots
Excavation
Ditching
Sloping/backsloping
Camber formation
Scour checks
Culvert laying
Mitre drains

Where individual task rates are inappropriate, the overseer will give team task works which have the following advantages:-

a) They are easier and quicker to set out and control than individual tasks.
b) It is easier to adjust team tasks if wrongly set without creating disatisfaction among the workers.

a) In earth works, the distance between the slots is often such that it provides a suitable one day task for a group.

d) Unforeseen difficulties will be evened out among several workers instead of being one persons burden.

The size of the team should be such that each worker has ample space to work in and the total number in any one group should not exceed 10.

3.2.1 SETTING TASKS

Tasks shall be set out by the overseer together with the headman.

The overseer shall:

Step 1 Measure and set out (with pegs) the volume of work for next day.

Step 2 Assess the task-rate which is applicable to the set out work.

Step 3 Divide the volume of work by the rate, (this gives the number of men needed to do the work in one day) and round off to the nearest whole number.

Step 4 Check if that number of men can work on the activity at the same time. (overcrowded sites reduce productivity and increase injury risk)

Step 5 Ensure that the headman knows about the exact location of the work on the day before the execution, how many labourers will be needed and which tools they shall require.

Step 6 Each morning, visit the sections on task-work and check that the strings have been properly set up and that the appropriate number of labourers are assigned to the task.

The headman shall:

Step 7 On the day of execution, set out strings between the pegs set out by the overseer to show the limits of the task.

Step 8 If the task-working team is short of labour when they show up for work, fill up the task-working force from non-task-working groups.

3.2.2 CHECKING WORK

When inspecting the work, the overseer should ask himself

a) Have the measurements been kept? (check with templates)
b) Are the edges straight and trimmed?
c) Is the soil placed correctly?
d) Is the section free from humps and depressions?
e) Is all other work included in the task completed?

If the answers to these questions are in affirmative, then the labourers should be released for the day.

If the answer to any of the questions is negative, then the group shall correct their work before being allowed to leave the site.

If the task has not been completed before the end of the nominal day, the overseer shall use his experience to judge whether the cause for this lies with the workers of in his own setting of the task.

If the reason for non-completion is a result of one of the following, the workers shall then be released at the

nominal working day:-

a) Major unforeseen difficulties (rock, roots etc)
b) Incorrect measurement or calculations of the task.
c) Smaller labour force than ordered.

However, if the reason for non-completion lies with the workers, they should complete the task before leaving even if it means working after 15.30 hours.

3.2.3 ADJUSTING TASKS

If the task has been completed in less than 5 hours for more than three consecutive days, the overseer should reconsider if the task is too low.

If after the labourers have been working for one week and the task has not been completed in time for three consecutive days, the task might have to be reduced, i.e. less volume given to the same number of workers.

3.2.4 TASK RATES

The task rates to be used in MRP have been derived from the ten pilot sites set up for that purpose. Other task rates have been adopted from RARP, however, adapted to suit the different conditions of MRP.

If the task is correctly rated and set, and the workers working at a good pace, the task should be finished in 6 - 7 hours. This applies only to the average worker. There will thus be some who will work faster or slower. However, when working as a team, nobody shall leave the site before the whole task is completed.

Activity	Unit Task Rate	Linear Task Rate Per Manday — Cross Section Type A	B	C	D	Remarks
Bush clearing	300 - 1000 m^2/md	30-80m	20-70m	30-80m	30-80m	Quantity according to the nature of the bush and the experience of the site supervisor.
Stripping & grubbing	200 m^2/md	20m	15m	20m	Only if necessary	Where bare ground exists, the taskrate should be increased.
Tree & stump removal	According to experience	–	–	–	–	For small stumps t.r. in metres, for big ones and trees in No.
Boulder removal	– " –	–	–	–	–	
Slotting	– " –	4 slots	3 slots	3 slots	–	In flat terrain the task rate should be increased.
Excavation to level	3 - 4 m^3/md	–	–	–	–	For cuts less than 0.5m high, (20m done by 3 labourers.) For cuts more than 0.5m high, depending on soil type.
Ditching	3 - 4 m^3/md	14-20m	12m	25-35m	–	Equivalent to 3-4 m^3/md depending on soil type.
Spreading	25 m^3/md	60m ditches spoil only	35m ditches spoil only	Not applicable	–	
Sloping	3.5 - 4.6 m^3/md	16-22m	22m	23-30m	–	Equivalent to 3.5-4.6 m^3/md, depending on soil type.
Backsloping	3.5 - 4.6 m^3/md	20-60m	25m	See Remarks		Depending on height of cut and soil type.
Camber formation	30m/md	30m	30m	30m	30m	
Mitre drain	3 - 4 m^3/md	–	–	–	–	
Scour checks	4No/md	–	–	–	–	Including prep. stones or pegs.
Culvert laying	18 md per line	–	–	–	–	Group task for excavation trench, laying rings, backfilling, compaction, and headwalls.
Catch water drain	3 - 4 m^3/md	–	–	–	–	Depending on soil type.
Hauling	5.5-13.5 m^3/md	–	–	–	–	(see also next page)

Task rates for hauling by wheelbarrow

The taskrate will depend on the hauling distance:

Hauling distance	Taskrate measured in site
0-20m	13.5m^3/manday
20-40m	10.5m^3/manday
40-60m	8.0m^3/manday
60-80m	6.5m^3/manday
80-100m	5.5m^3/manday

3.3 IMPROVEMENT WORK ORGANIZATION

It is proposed that the improvement works shall be carried out in as similar manner to the RARP with the exception that it may be necessary for earthworks to be compacted directly and measures will be taken to cope up with the traffic using the road. A flexible approach will be required because the improvement works will differ from one road to another. At one extreme, a road may require simply the installation of drainage on some sections of it, and a few lines of culverts, while another one may need total reconstruction.

Prior to the recruitment of the labourforce, the Engineer and the officer-in-charge shall establish the centre-line of the road in co-operation with the landowners. The centre-line will be staked out using wooden pegs at 10m intervals. The Engineer will then prepare a simple bill of quantities together with a line diagram indicating the items and quantities of work to be performed.

To minimise the inconvenience to road users and to reduce the possibility of accidents because of the large number of labourforce involved, the roads will be closed where possible to through traffic whilst under construction. The alternative routes will be signposted and assistance of the District Administration will be sought to enforce these measures. Every effort will be made to accommodate the needs of local residents but it is not proposed to construct any deviations. In those cases where there is a substantial volume of traffic using the road during improvement, the work will be organised, as far as possible,so that the on-going activities are restricted to one side of the road whilst the other is open to traffic

The improvement of the road will commence when the first gang reports for duty to carry out "bush clearing". Three days later a second gang reports for duty and is assigned to "stripping and grubbing" and soon the labourforce is upto strength. The gradual build up gives the overseer an opportunity to provide some on the job training to each gang and to identify suitable candidates for appointment as headmen.

For the purpose of construction, the project will be sub-divided into equal sections of about 5 kilometres and all work will be substantially completed on one section before being commenced on the next.

The construction activities on each section will be carried out in two phases, initially the site clearance activities and excavation and filling to level are completed over a section of about 1 kilometre before the drainage activities are effected. This avoids the labourforce being spread out over long lengths of road and simplifies the Overseer's task by enabling him to spend a greater amount of his time personally supervising the work rather than walking between labour gangs. Furthermore the pause between excavation and filling to level and the drainage activities provides an opportunity for some consolidation of the earthworks to take place prior to the formation of the camber.

As a means of controlling the general standard of construction an inspection certificate is kept on each site. For each 200m section of road the officer-in-charge will be required to certify that he has inspected and approved: the alignment; the excavation and filling to level, the profile of the side drains and camber-formation, and the installation of culverts and miscellaneous drainage. As each stage is completed, it must be inspected and approved prior to continuing with the next operation.

Camberboards and templates will be provided to assist the labourers to achieve the required side drains and camber profiles. It is important that on completion the excavation and filling to level is absolutely level transversely and free from humps and hollows longitudinally.

A procedure termed slotting will be used to calculate excavation volumes and also to show the workers the required finished excavation levels. Slots will be excavated perpendicular to the centre-line of the road at 10m intervals. The slots are excavated to the desired width and level of the road terrace.

With regard to the compaction of earthworks, a decision has been made to develop an animal or hand drawn deadweight roller for use without watering of the soil. The use of tractor drawn rollers or loaded trailers is to be discouraged as it is an inefficient use of resources.

As with the RARP, it is proposed to equip the gravelling units with farm tractors and single axle trailers for hauling the gravel surfacing material. Before reaching this decision, a number of alternatives were considered including farm tractors and twin axle trailers, cargo trucks, dump trucks and trucks equiped with removable skips. Taking into account the operating conditions, it was decided that the proposed system offered the best compromise, a view which is shared by the sugar industry where tractor-trailer combinations are used to haul canes from the field to the mill.

Taking note of past difficulties, experienced in achieving gravelling targets, a number of changes are proposed which should help to improve the overall performance. Consideration will be given to increasing the capacity of the trailers from 2.8 cum to 4 cum equivalent to about 8 tonnes, the maximum load permitted on a single axle. This will have the effect of reducing the number of tractor and trailer combinations required to achieve a given output which is in turn should reduce the management and supervision problems.

In addition it is proposed to separate the tasks of quarry preparation and gravelling operations. The former will be carried out as advance works prior to transferring any equipment and should improve the output of the gravelling units by reducing the amount of equipment idle time.

In those districts where the average hauling distance for gravel exceeds 10 km it is proposed to supplement the gravelling by tractors and trailers by gravelling either using tippers available within the Ministry or by contract. These districts include Kericho, Kiambu, Kwale, Murang'a, Nandi, Nyandarua, Nyeri and Uasin Gishu. Similary, in other districts for specific roads where the average haul distance exceeds 10 km and the DMI Engineer considers it to be necessary, he may be authorised to let a contract for gravelling.

3.4 IMPROVEMENT METHODS

The improvement activities of the roads will be executed in a sequence. This will be done in order to simplify supervision and enhance workmanship. The operations and activities of the improvement works are listed below in the order in which they will be executed. However, the construction of major structures shall be started as a separate self contained operation due to the problems of coordinating the required resources.

The operations are illustrated in the diagrams accompanying the text for the Standard Cross Section: A.

Sequence

STAGE 1

OPERATION	ACTIVITY	FOR DETAILS SEE:
SUPPORTING	Setting out Work at camp Water supply Erosion protection	
PREPARATION	Bush clearing Grubbing Tree and stump felling Boulder removal	
FORMATION	Slotting Excavating and filling First compaction	
DITCHING	Ditching Spreading Second compaction Sloping Backsloping Camber Formation Final Compaction	
DRAINAGE	Mitre drains Scour checks Culvert laying	
MAJOR STRUCTURES	Multiple line culverts Drifts Bridges	

STAGE II

OPERATION	ACTIVITY	FOR DETAILS SEE:
MURRAMING	Quarry preparation Excavation Loading Hauling Spreading Compacting	

3.4.1 Supporting Activities

The supporting activities include:-

i) Work at camp
ii) Drawing water for site overseer and casual labourers
iii) Watchmen
iv) Casting of culvert rings (at base camp)
v) Storekeeping
vi) Masonry work
vii) Tool repairs.

3.4.2 Setting out alignment

The setting out of the basic alignment should be done by the Engineer at least 3 months before the start of improvement works and the land owners notified through the local administration (Chiefs) not less than 6 months before construction starts. This must be done to minimize crop compensation claims and land problems. When passing through highly agricultural land, the horizontal alignment should follow existing road wherever technically feasible.

Method : In the initial setting out, only straight lines and intersections need to be set out. The centre line should be marked with wooden stakes, 4 x 4 x 150 cm, driven securely into the ground and painted at the top. The Chainage, as measured with the line or tape, should be written with a water proof pen on the stakes. The distance between the stakes should not be more than 50m.

Tools : Ranging rods.
Inclinometer or Abney level
Stakes, 4 x 4 x 150cm, sharpened at the end and painted at the other.
50m Measure Line (tape).
Mallet (For driving the stakes down).
Water proof pen.

Control: Check the set out centre line against the standards

3.4.3 Final Alignment

The final setting out of the alignment should be done by OiC and it should as far as possible follow the preliminary alignment.

The final setting out of the alignment should include curves and levels and should be carried out as the first improvement activity.

Method: Straight lines are set out with ranging rods, and circular curves set out using offset method. The same kind of stakes as in the preliminary setting out should be used.

The excavation level (or in fill, the height of fill) shall be marked with a painted line on level pegs or stakes The pegs or sticks should be placed as follows:-

a) In cut-and-fill, at the intersection between cut and fill.

b) In cut-to-spoil, at the down hill side of the limit of excavation.

c) In fill, at the bottom limit of the fill.

Tools: Ranging road
Inclinometer
Boning rods
50m measure line (or tape)
Mallet
Paint
Stakes (to replace lost preliminary stakes)
Pegs

Controls:- Check the alignment against the standards.

3.4.4 Setting out cross sections

This shall be done by the Overseer before the start of the improvement works and includes measuring of the chainage.

Method: The limits of the road (the top of the back-slope and the foot of the fill) should be measured from the centre line of the road and pegged out every 20 metres along the road

The chainage should be written on the up-hill side peg with a water proof pen.

Tools: Measure tape
Pegs
Water proof pen
Mallet
Spirit level.

3.4.5 Work at Camp

Work at camp starts with the preparation of camp site and erection of huts.

After that, intermittent work at camp might be needed to repair huts, drain water etc.

3.4.6 Supplying Water

Drinking water must be supplied to the workers on site. This is drawn from the nearest suitable water source by casual workers. Water for the site camp is supplied in the same way and stored in drums.

3.4.7 Erosion protection

It is necessary to protect the embankment, slopes drains and road surface against damaging erosion by heavy rains.

This protection includes:-

- Planting of grass or grass turfs on side and bank slopes
- Building of scour checks
- Proper maintenance of road surface and drainage
- Compacting fills.
- Erosion control measures in existing adjacent gullies.

3.4.8 Planting of grass

Grass is very effective in preventing erosion and should be planted on all slopes where scouring is likely to occur. The type of grass to be used should be strong, fast growing and covering. Grass removed by the grubbing gang can often be used if collected and stored properly.

Method: Collect grass runners removed by the grubbing gang and store in a heap which is kept damp and in the shade.

On the day of planting, cut the grass runners in pieces of approx. 20cm. These pieces are then planted in rows with 10cm in the ground. The distance between the grass plants should not be more than 30cm. The rows should be skewed so that a zig-zag pattern is obtained.

The plants should be watered as required to make them take root.

Tools: Panga
Watering can
Stick (for making the hole to plant in)

Task: In flat areas and with a 30cm distance between the plants, a person can plant approx. 200m^2 per day.

Setting Out: The planting stick should be 30cm long and the planter should himself check so that nowhere is the distance between the plants larger than 30cm.

3.4.9 Turfing

(Grass) Turfs give a faster and more effective protection to slopes than planted grass. Turfs can often be cut in the grubbing activity. The size of the turfs should not be smaller than 20 x 20 cm.

Methods: Estimate the area to be covered and cut the corresponding amount of turfs.

The turfs are cut in squares not smaller than 20cm x 20cm and thick enough to ensure that enough roots are left in the turf for effective rooting

Store the turfs in stocks which must be kept damp and in the shade.

Before placing the turfs, the soil should be watered.

Place the turfs edge to edge and water as necessary until they have rooted.

Tools: Jembe (for cutting the turfs)
Watering can

Tasks: The difference in type of turfs, soils and slopes make task work difficult to use. Daily work is preferable.

Setting Out: This does not need any setting out.

3.4.10 Site Clearing (Preparation)

The site clearing is the first of the operations to start when the alignment has been set out.

Site clearing includes:
- Bush clearing
- Tree and stump removal
- Grubbing (vegetation removal)
- Boulder removal

Normally the improvement width plus one metre shall be cleared.

Trees shading the road hinder a fast drying out of the road after rain and should be cut down unless that creates risks of erosion. Unnecessary cutting down of trees shall, however, be avoided - e.g. instead of going straight through a group of trees the road could be taken around it. Compensation might have to be paid for trees that bear fruit or nuts and in such cases cutting down should be done very restrictively.

Felled trees belong to the land owner as well as all crops removed. A record of all cash crops removed (including trees) must be kept for calculation of crop compensation.

Three months before the start of construction the basic alignment should be set out. No compensation will be paid for crops planted after the announcement of intended road improvement.

Blasting of boulders can be justified in extreme cases. The Engineer has however to contract such blasting to a licenced contractor or arrange it through the Provincial Engineer.

3.4.11 Bush Clearing

Bush clearing consists of cutting and removing all bushes and shrubs within the improvement width plus one metre. The bushes shall be disposed off outside the roadway.

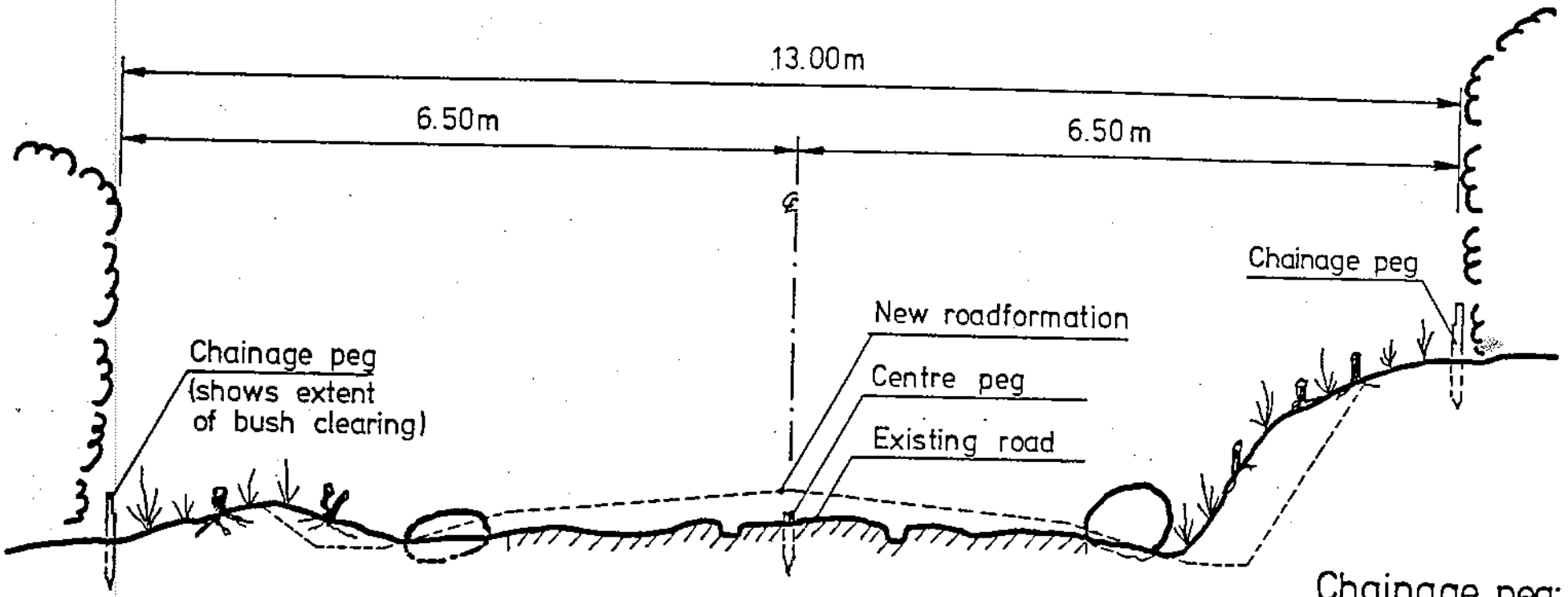
Tools: Pangas
Sharpening stone

Method: The workers are spaced at least 10 metres apart and working away from each other, cutting the bush with pangas. If the bush has sharp thorns, a stick with a 'hook' is useful for holding the bush and throwing it outside the road.

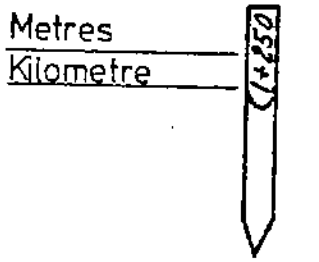
If the bush cannot be disposed of outside the road because of shambas, then heaps should be made along the centre of the cleared areas. These heaps should then be burned when the vegetation has been removed (after grubbing) and when there is no danger of the fire spreading.

Task: Though the taskrates have already been proposed, it is difficult to assess parametres for this activity and the taskrates given can be changed if the Overseer has personal experience of the particular type of bush.

BUSH CLEARING



Chainage peg:



Disposal of shrubs :

Outside the 13.00m wide strip of bush clearing, preferably on the lower road side.

3.4.12 Stripping and Grubbing

The activity includes the removal of all topsoil, grass upper grass roots and other vegetation (except bushes and trees) over the width of the improvement plus one metre and the disposal of all removed matter outside the grubbed width.

Step **1)** The overseer shall measure the area to be cleared the next day and assess grass type. No grubbing is needed if the soil is going to spoil.

2) Select the appropriate rate based on your experience or the taskrates previously given.

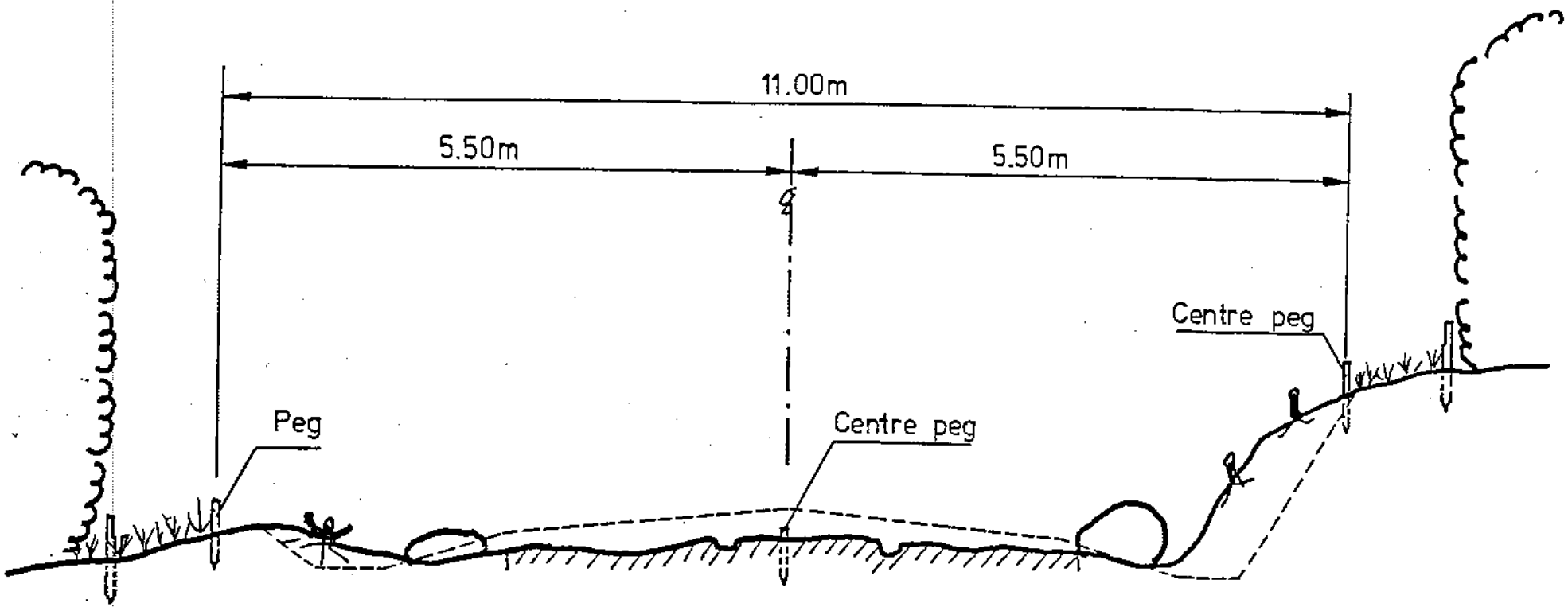
3) Calculate the number of workers needed by dividing the area by the rate.

4.) Set out the task together with the headman and instruct him about the numbers of workers and the number and types of tools needed.

Suitable tools:

Jembe , Spreader and Shovel.

STRIPPING & GRUBBING



3.4.13 Tree and Stump removal

This includes the felling of trees and the removal of them outside the roadway as well as up-rooting and disposal of stumps.

Tools:
- Shovels, Jembes, Mattocks) For exposing the roots
- Axes — For cutting the roots
- Long ropes — For pulling down the trees
- Crowbars — For moving the log.

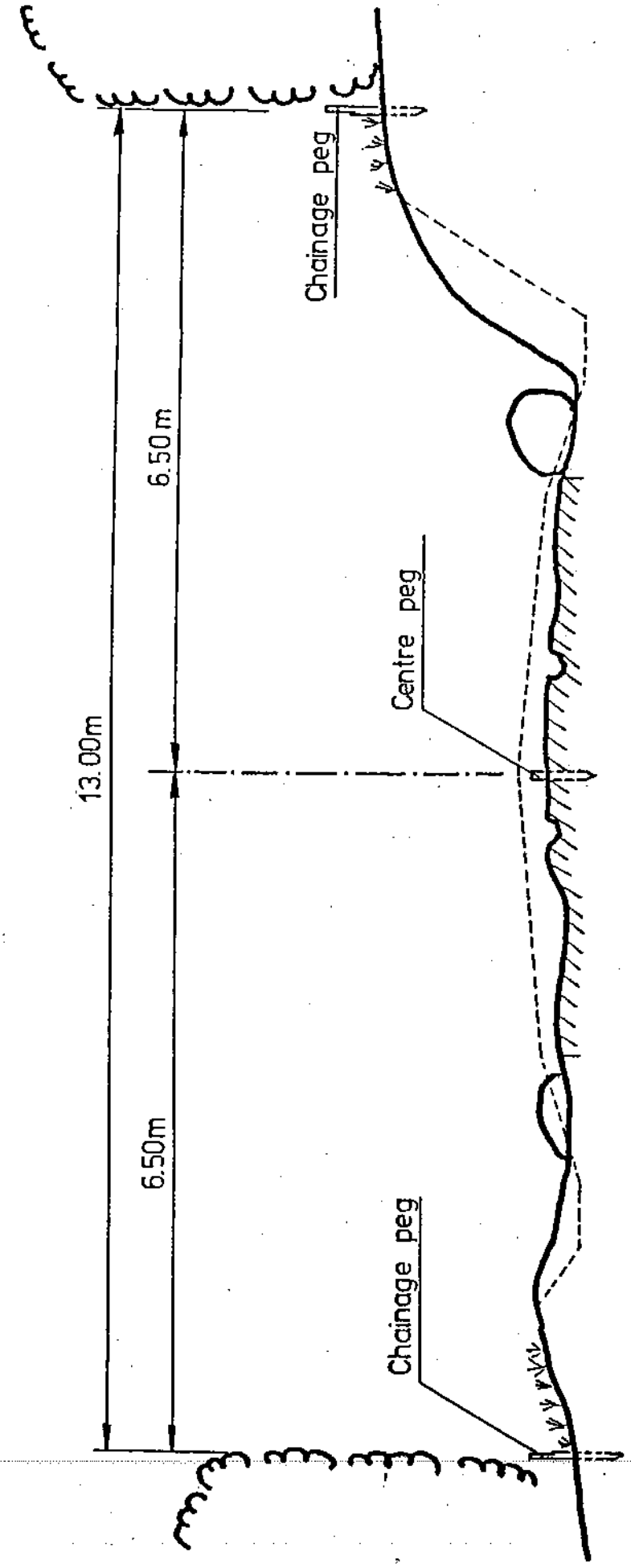
Method: The soil around the roots is removed through excavation (stumps are up-rooted in the same way) and a long rope is secured to the top of the tree. When the roots have been sufficiently exposed a number of men will pull on the rope in the direction the tree is supposed to fall. Trees with shallow roots can often (and preferably) be pulled down without cutting the roots while the roots of deep-rooted trees normally have to be cut.

When the tree has been felled, it has to be cut so it can be removed from the roadway.

Extremely big roots and stumps which cannot be cut should be burned after grubbing has been carried out.

Task: Since the roots of the trees differ greatly, task work can be used only if the overseer has personal experience of removal of trees of that particular species.

TREE & STUMP REMOVAL



3.4.14 Boulder removal

Boulders are not frequent in all areas but where they occur in the alignment it means considerable extra work.

If possible the alignment should be changed but if that is not possible, the boulders will have to be removed either by rolling them away, burying them or cracking them by fire and water, blasting or by chisels and hammers.

Tools: Crowbars
Sledge-hammers, 6kg, with one quarry chisel end
Hand drills and hammers
Jacks
Tools for excavating hard soil

Methods: Depending on the size, shape and position of the boulder different methods are possible.

a) Moving boulders outside the roadway

This is only applicable to boulders of less than ½m^3. The boulder is moved by using crowbars as levers after the boulder has been dug out. Pieces of rail are useful for sliding the boulders on.

b) Burying boulders

If the boulder is bigger than ½m^3 and/or lying deep in the soil it is often most effective to dig a hole next to the stone (big enough to accommodate the stone) and bury it.

An alternative to be used if the soil is too stony to make a hole is to fill over the stone (raising the whole alignment).

c) Cracking the boulder by fire and water

If only a tip of a large boulder is to be removed it can be cracked by making a fire on the part to be cracked and, when the stone has become very hot, pouring cold water over it and hammering it with sledge-hammers.

This method is however often ineffective and should be used sparingly.

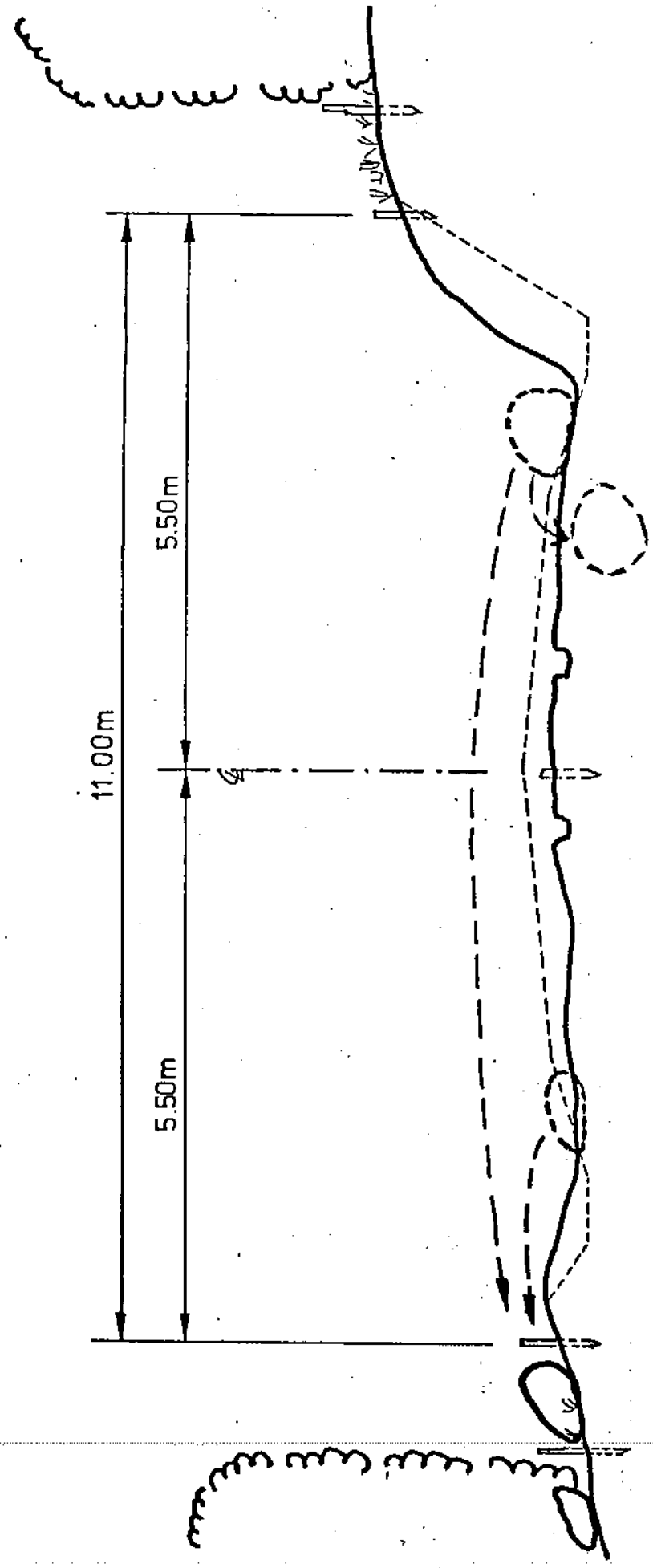
d) If the rock is weathered and cracked to some extent, it is often possible to crack it into smaller pieces by using wedges and hammers.

e) Cracking by explosive

If there is a very large number of big boulders or rocks, blasting is justified. The blasting must be done by a licenced blaster.

If boulders are buried or only partially removed very good compaction is needed around them to prevent uneven settlement.

BOULDER REMOVAL



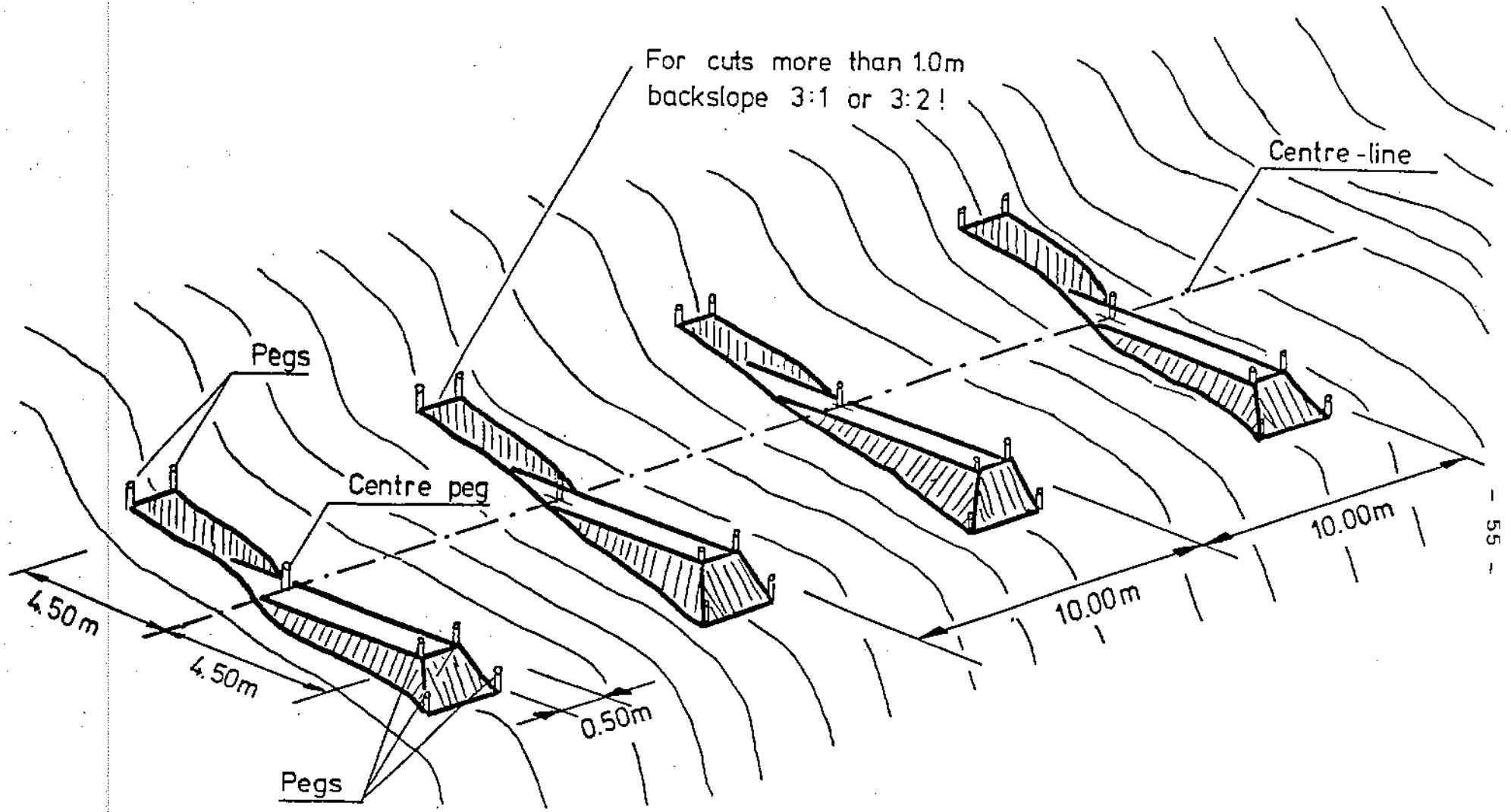
3.4.15 Slotting

Slotting is a practical way of enabling the Overseer to measure and calculate the volume of soil to be excavated. In addition to this it also serves as an indestructible mark of the correct level.

Method: A 'slot' is dug at right angles to the centre line to the correct road width and level. The slot thus shows the real cross-section of the part to be excavated. The slot should only be as wide as necessary.

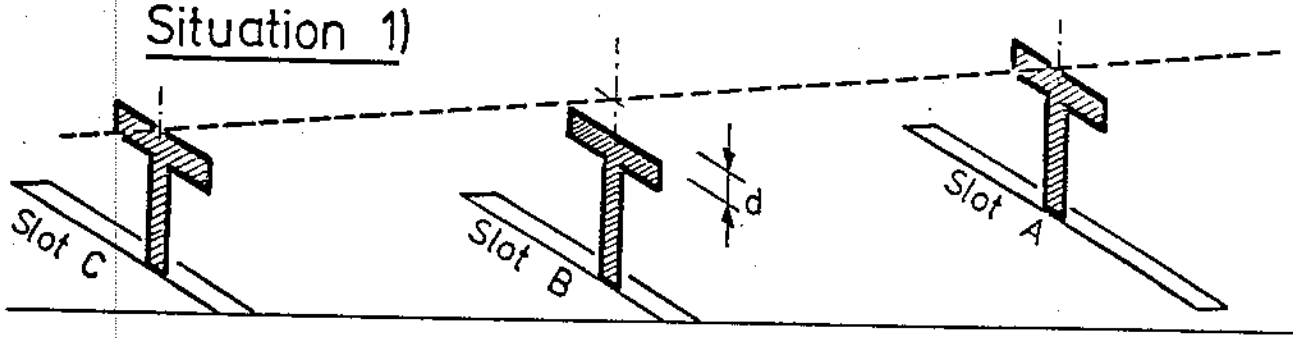
The distance between the slots shall be 10 metres.

SLOTTING


For cuts more than 1.0m
backslope 3:1 or 3:2 !
Centre-line
Pegs
Centre peg
4.50m
4.50m
0.50m
Pegs
10.00m
10.00m

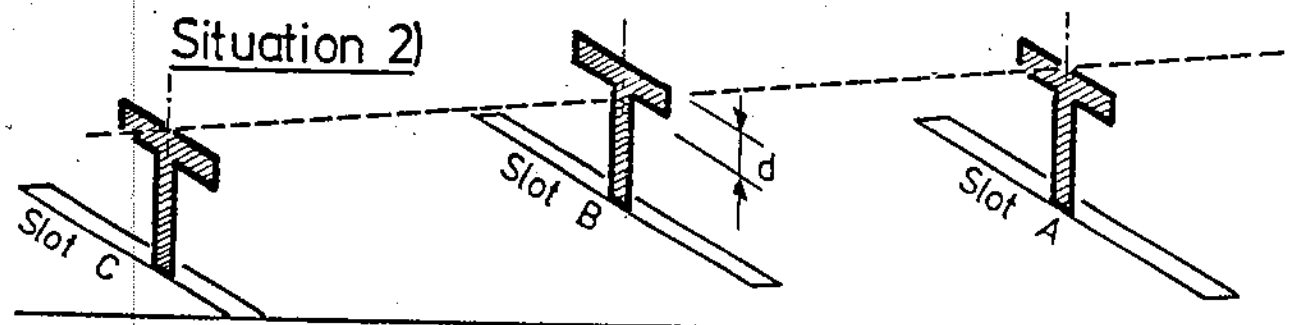
LONGITUDINAL BALANCING

Situation 1)



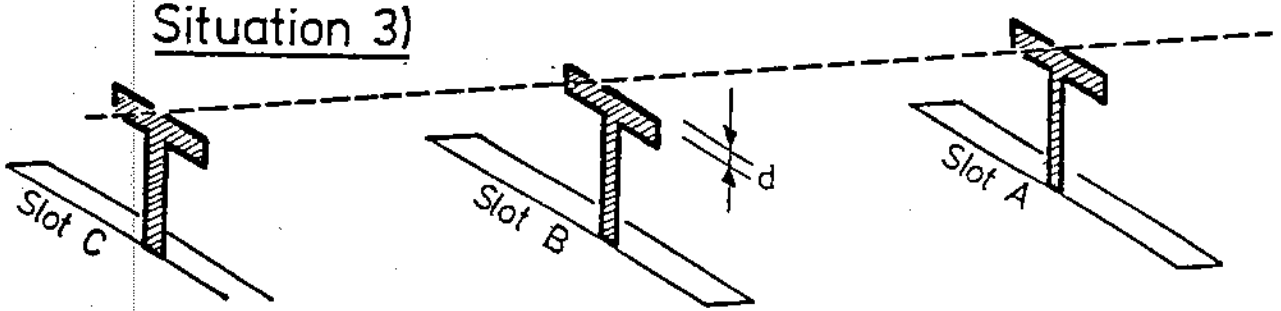
Slot B is lower by more than 15cm from the uniform gradient slot A - slot C. The level of slot B is raised by borrowing material from slot A and slot C until d is less than 15cm.

Situation 2)



Slot B is higher by more than 15cm from the uniform gradient slot A - slot C. The level of slot B is lowered by transporting material to slot A and slot C until d is less than 15cm.

Situation 3)



d is less than 15cm; no longitudinal balancing is needed.

3.4.16 Earth Works (Excavation and fill to level)

The objective of this operation is to provide a transverse level 'terrace' with an even longitudinal slope. On this 'terrace' the drains and camber are built as the next improvement operation.

The excavation and filling in usually the most time consuming single activity, and most essential to be done correctly otherwise the camber would be difficult to properly construct. Longitudinal hauling with wheelbarrow should be avoided, and is recommended that the borrow should whenever possible be taken from the side of the road.

Materials in fills shall be spread in thin layers and compacted with hand rammers or by a deadweight roller where available.

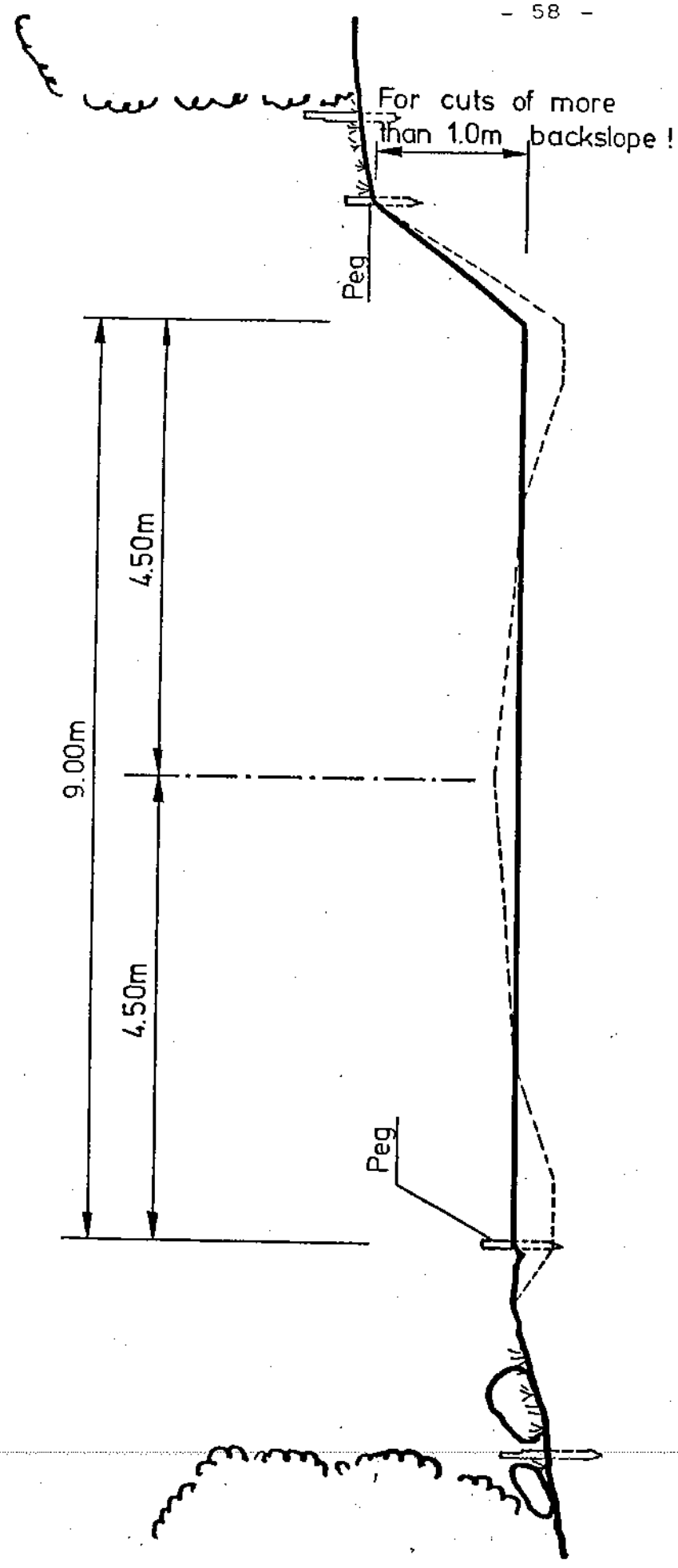
The in-situ materials will be used as the subgrade of the road. Sections with poor material shall however be elevated and improved by a wearing course of good murram.

Black cotton soil presents unique problems because of its enormous expansion when wet, and satisfactory construction methods on this material will be required such as raising the road above the existing ground level. See section B.

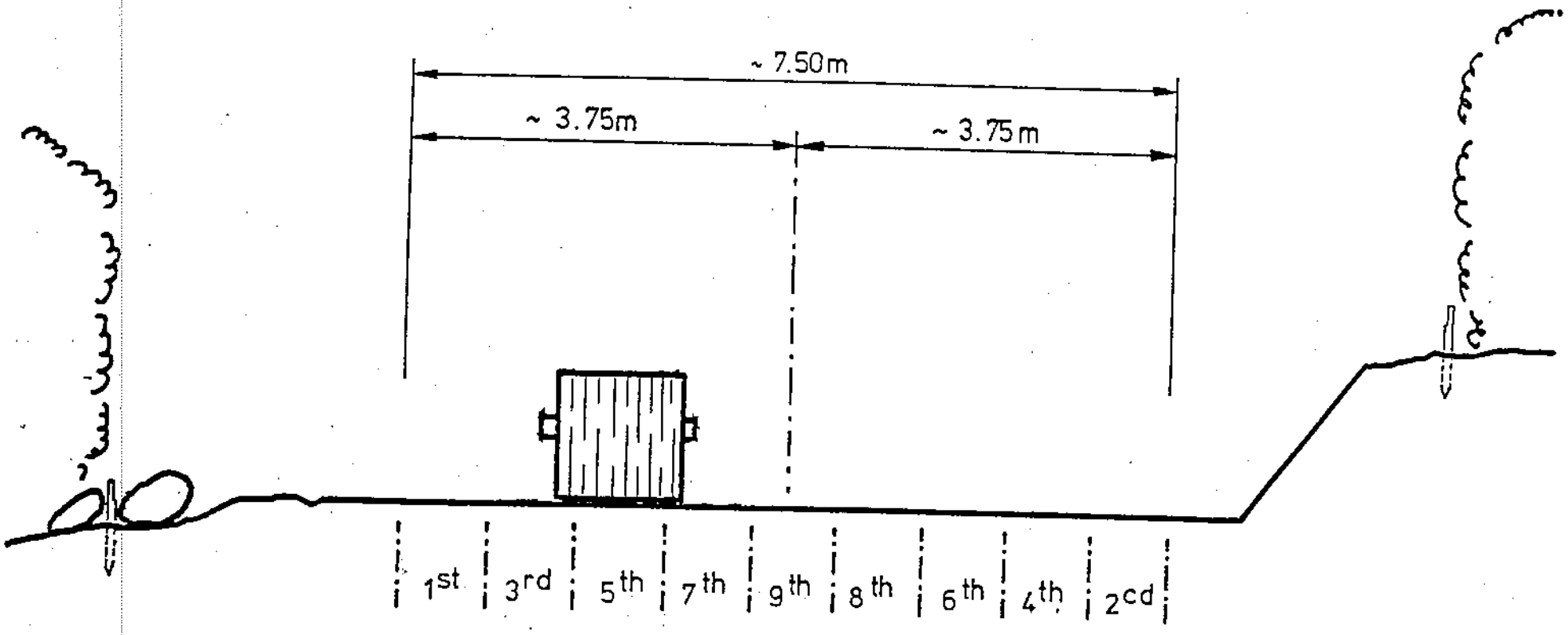
When the site clearing has been done, the slots will be constructed and the excavation to level,'terrace'be formed by levelling and cross filling. In very steep crossfalls where there will be the risk of the fill sliding down the slope, it will be necessary to construct the road on the cut only. This is, however, a costly solution, and will only be used if the re-alignment of the road is not possible. The reduced Cross Section C will be used in these circumstances.

The spreading of the fill material shall be done in thin layers of about 15 cm. Each layer will be compacted with hand rammers or deadweight roller before the next layer is added.

EXCAVATION TO LEVEL



FIRST COMPACTION



BY HAND OR ANIMAL DRAWN ROLLER

3.5 DRAINAGE AND DITCHING

3.5.1 The drainage system

Water contributes to the wear and damage of the road. The water can be in form of ground water (inside the earth), surface water when it has reached streams, or rain (which will **become** surface water when it has reached and collected on the surface). Water can damage the road in two ways:

- by washing away the soil (erosion or scouring);
- by making the road less strong to traffic, (lowering) the road bearing capacity).

It is therefore very important to have a good drainage system which allows the water to flow off the road and away from it as quickly as possible. Such a system consists of several components:

- road surface drainage which makes the water flow off the road surface (camber);
- side drains which collect the water from the road surface;
- mitre drains which lead the water away from the side drains.
- culverts which discharge the water under the road from one side drains to the other.
- scour checks which prevent erosion in the side drains by slowing down the water;
- catch water drains which catch the surface water on the cuts before it reaches the road;
- sub-surface drainage which will lower the level of under ground water.

All these drains have to work together if the results are to be good.

It is the site supervisor, who has to set out, instruct labourers, control and decide whether the drainage system will serve the purpose.

3.5.2 Side Drains

The function of the side drains (or ditches) is to collect the water from the carriageway and surrounding areas and transport it to natural water disposal. The material excavated from the ditches is used to form the camber which in turn helps to drain the water from the road surface to the side ditches.

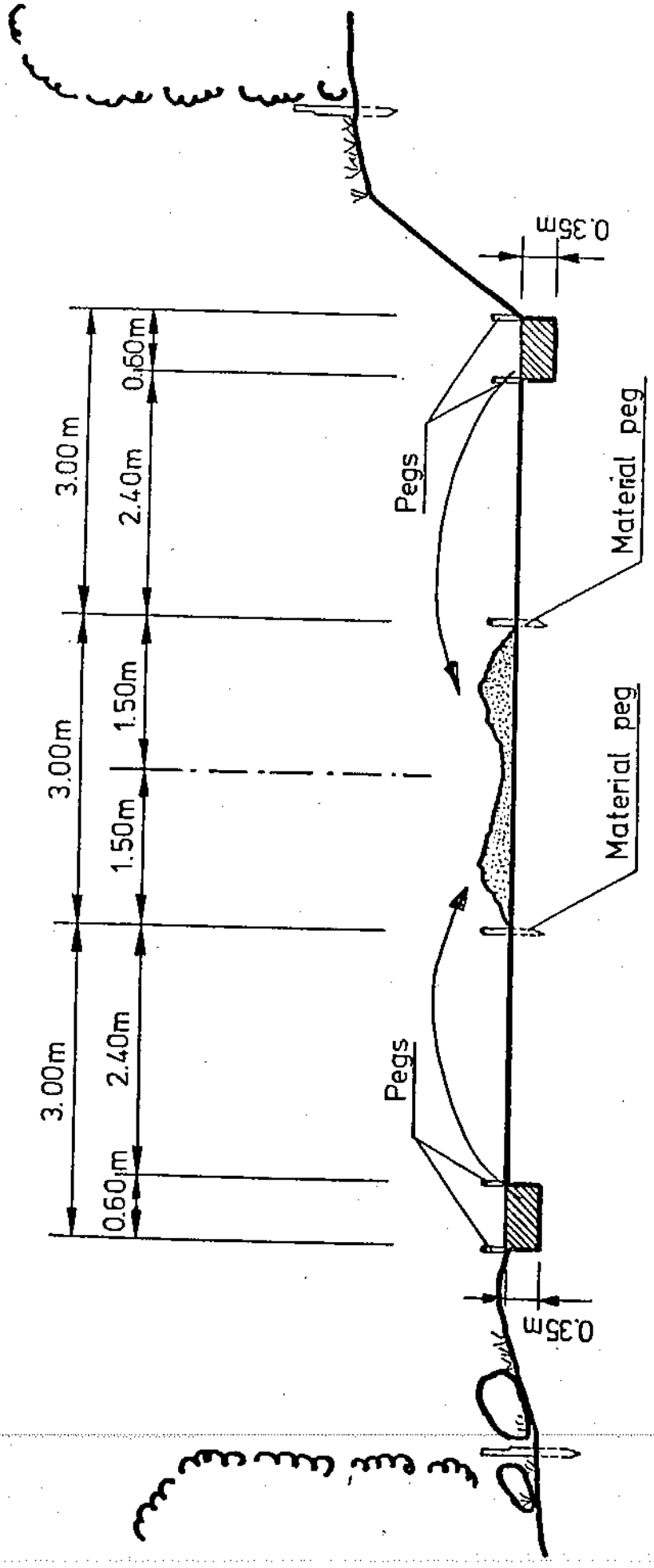
On flat or slightly undulating terrain the site supervisor should aim to achieve a longitudinal gradient between 2 and 5 per cent. With gradients less than 2% silting occurs easily, while with gradients steeper than 5% the ditches will erode easily. The side ditches are constructed in the three steps ditching, sloping and back-sloping. The reason for excavating the ditches in this manner and shape is that it is easier to measure and control than a traditional V-shped ditch made in one operation.

Tools: Jembe, forked jembe, mattock, pickaxe and shovel for the labourers strings, pegs, tape-measure and ditch template for the headman.

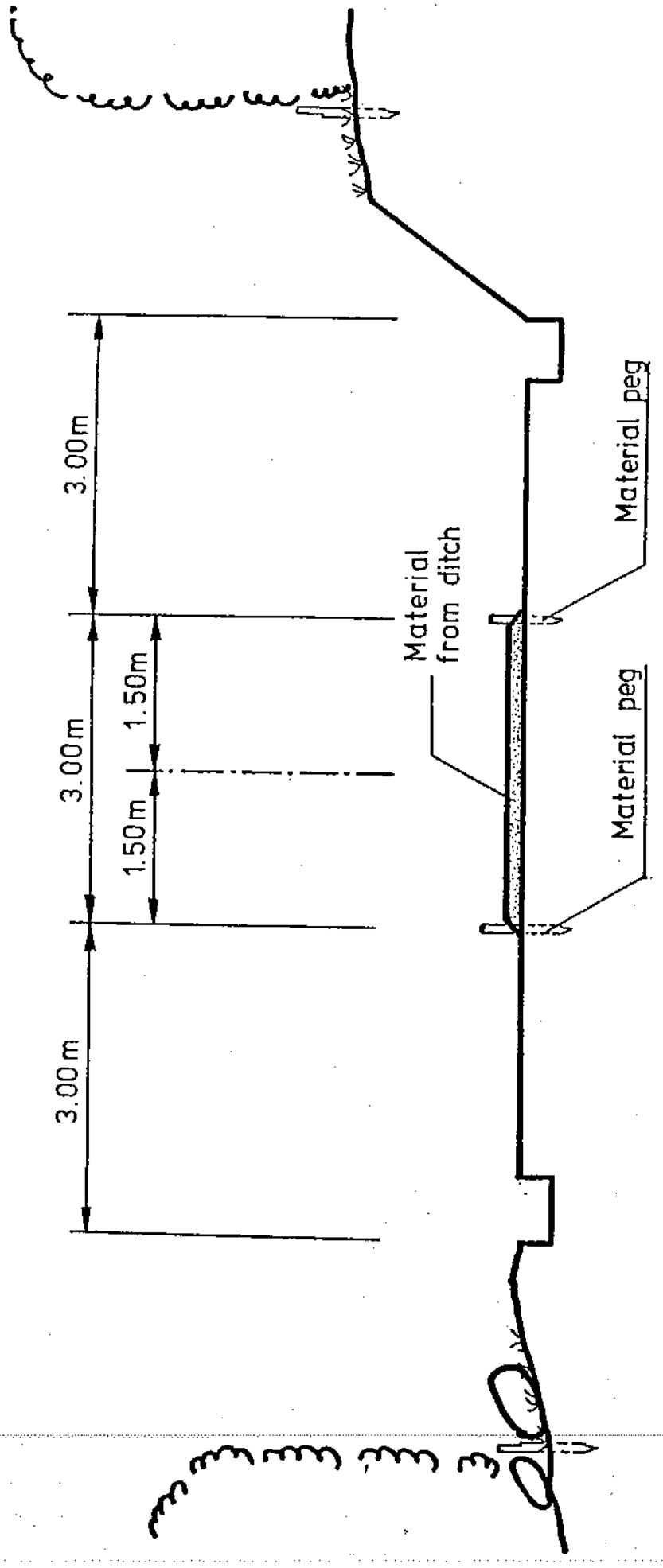
Check that:

- strings and pegs are used to show extent of ditch
- straights and curves are set out smoothly;
- correct tools are used;
- the soil is placed within 1,0m of the centre line.
- the width and depth are done to the correct measurements;
- the ditch template is used to control ditch measurements;
- roots are removed.

DITCHING


0.35m
0.60m
3.00 m
2.40m
Pegs
Material peg
3.00m
1.50m
1.50m
Material peg
3.00m
2.40m
Pegs
0.60m
0.35m

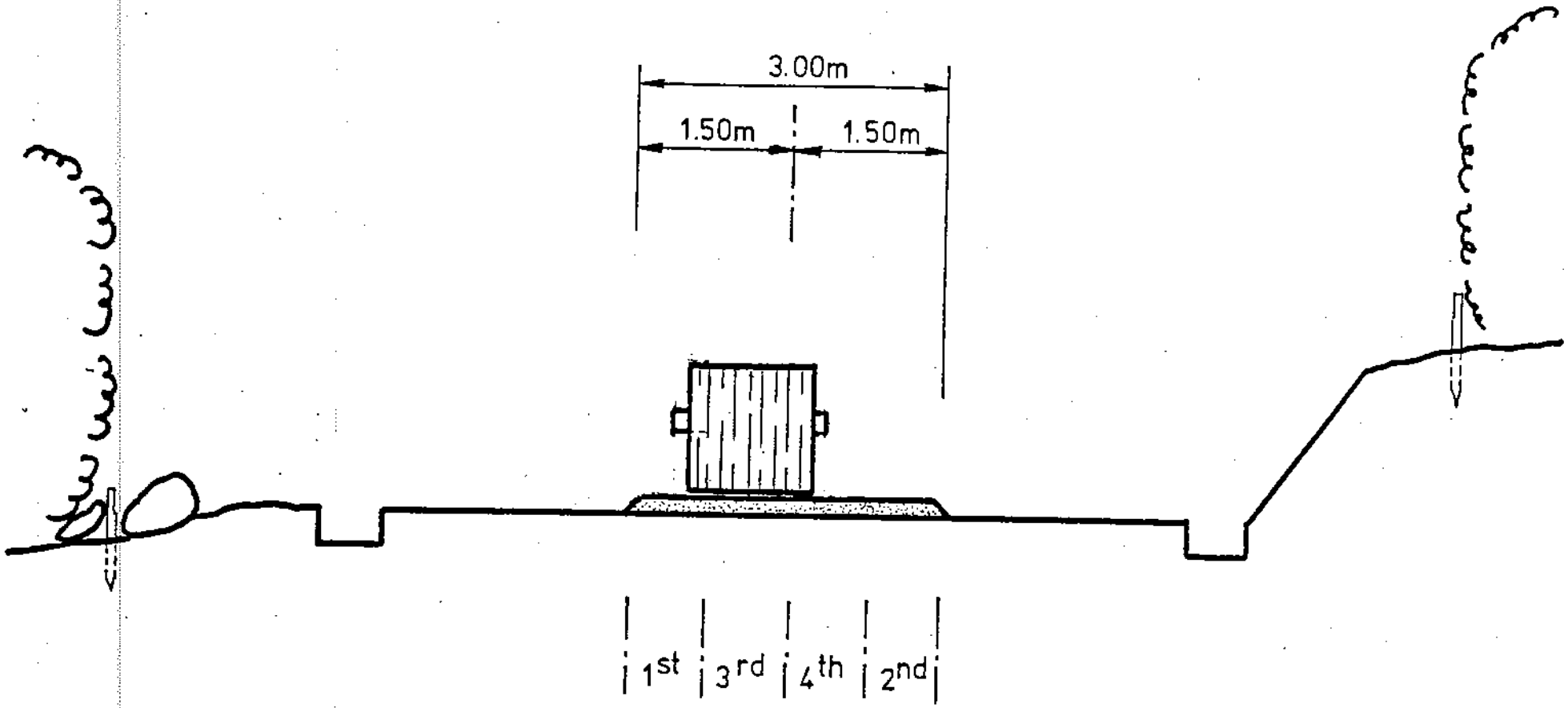
SPREADING


3.00m
3.00m
1.50m
1.50m
3.00 m
Material from ditch
Material peg
Material peg

3.5.3. Second Compaction

The material excavated by the ditching operation should be spread over the centre 3 metres of the cross section and compacted with hand rammers or a deadweight roller.

SECOND COMPACTION



BY HAND OR ANIMAL DRAWN ROLLER

3.5.4 Sloping

The side slope should allow a smooth flow of the surface-water from the carriageway into the side ditch. The material from sloping is also used to form the camber. The material of the triangular section between the bottom of the ditch and the edge of the carriageway is excavated and thrown to the centre.

Tools: Jembe (mattock or pickaxe in case of stony or hand soil,) and shovel.

Check that:-

- the strings are used to mark the area of work;
- a smooth setting out of straights and curves done;
- correct tools are used;
- the soil is placed within 3.0m of the centre-line, between the material pegs;
- roots are removed;
- a uniform slope is excavated;
- the ditch and slope templates are used to control the work.

3.5.5 Backsloping

Backsloping is done in order to prevent soil from falling into the side ditches and blocking the drainage system. In addition, it provides material for the camber. It is the responsibility of the site supervisor to form a stable backslope.

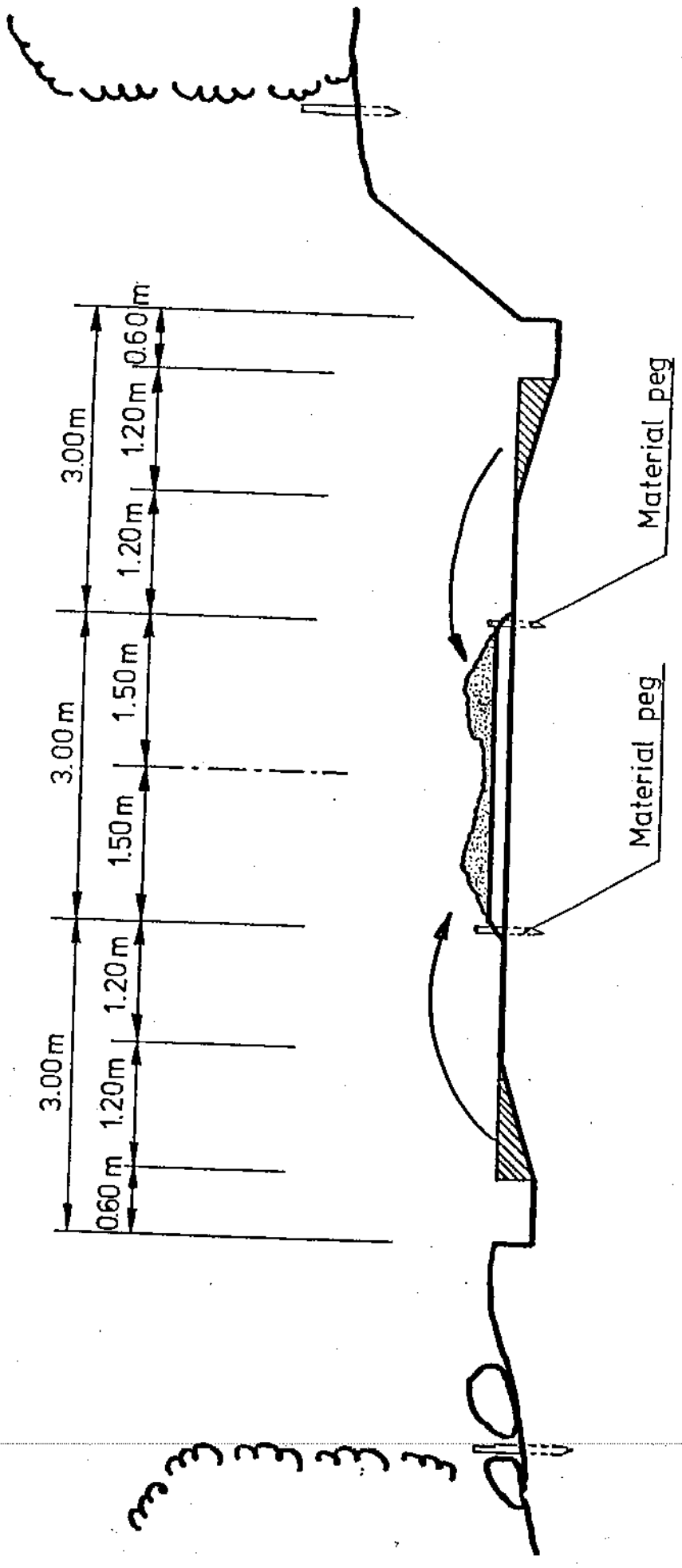
Tools: Jembe , (mattock or pickaxe for hard and stony soils) and shovel

Taskrate: 20.0-60m/md depending on height of cut and the hardness of the material.

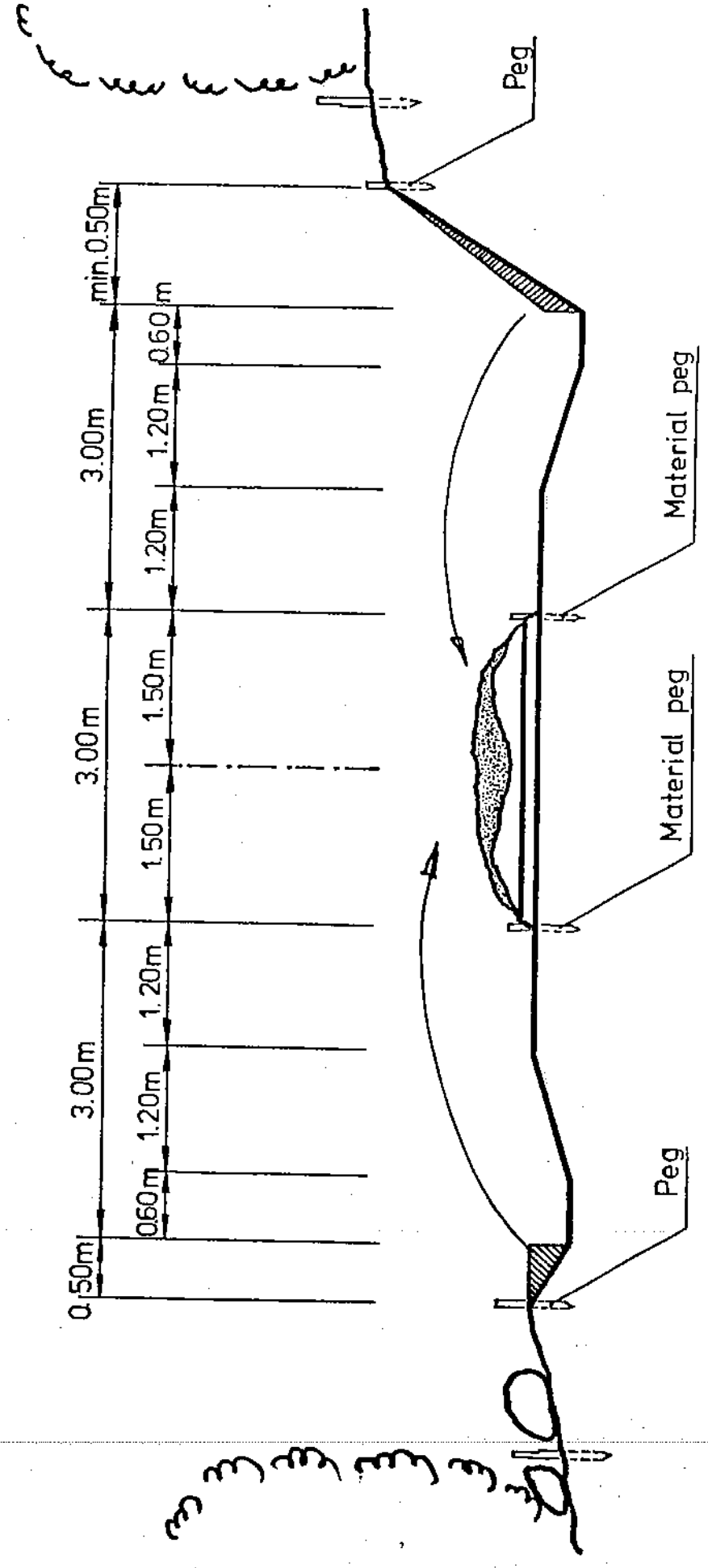
Check that:

the correct width is set out;
- strings are used;
- the soil is placed within 3.0m of the centre line, between material-pegs,
- roots are removed;
- uniform backsloping is done.

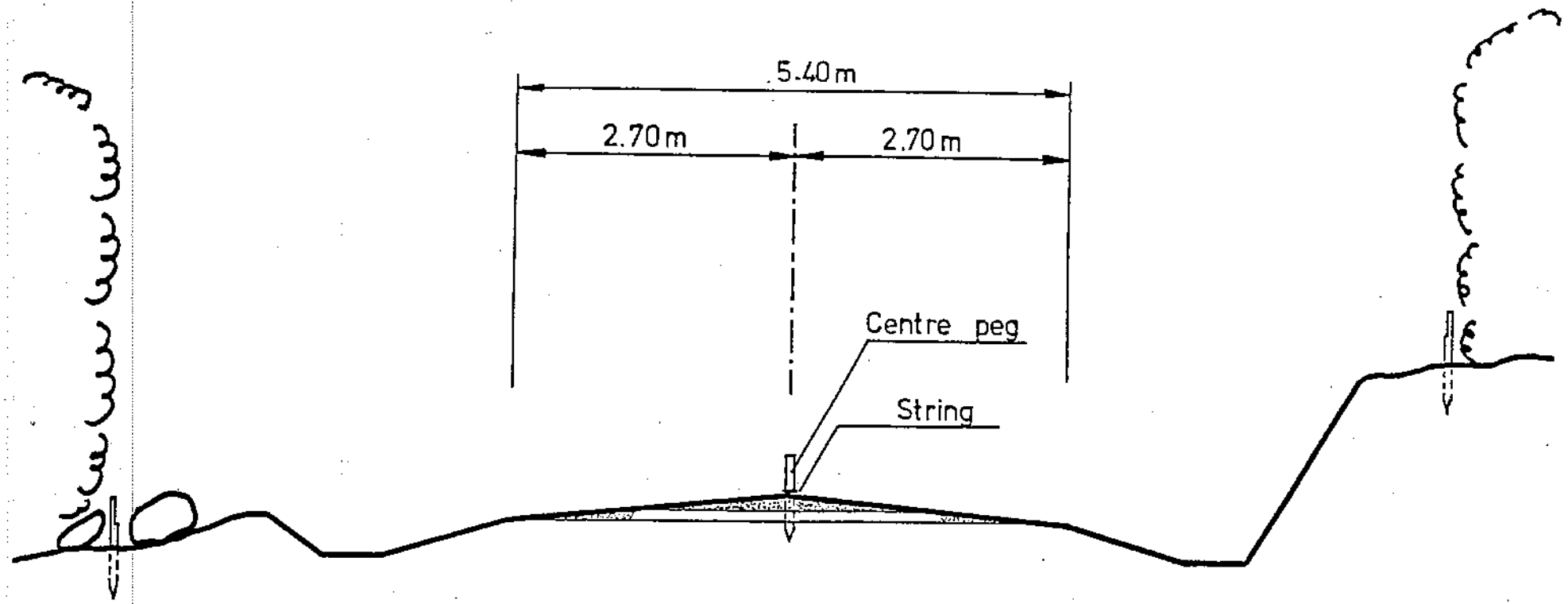
SLOPING


0.60 m
1.20 m
1.20 m
3.00 m
1.50 m
1.50 m
3.00 m
1.20 m
1.20 m
3.00 m
0.60 m
Material peg
Material peg

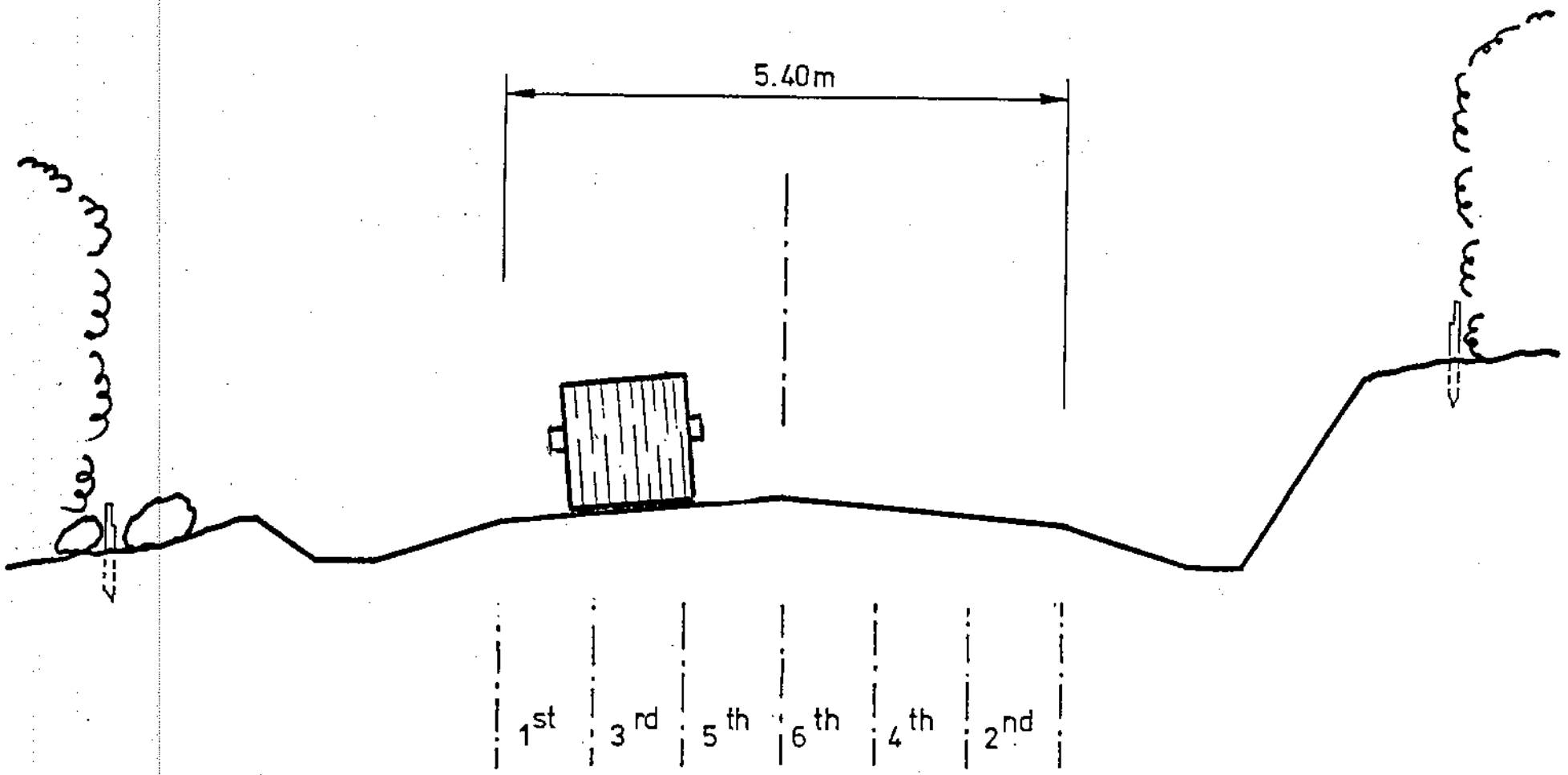
BACKSLOPING



CAMBERFORMATION

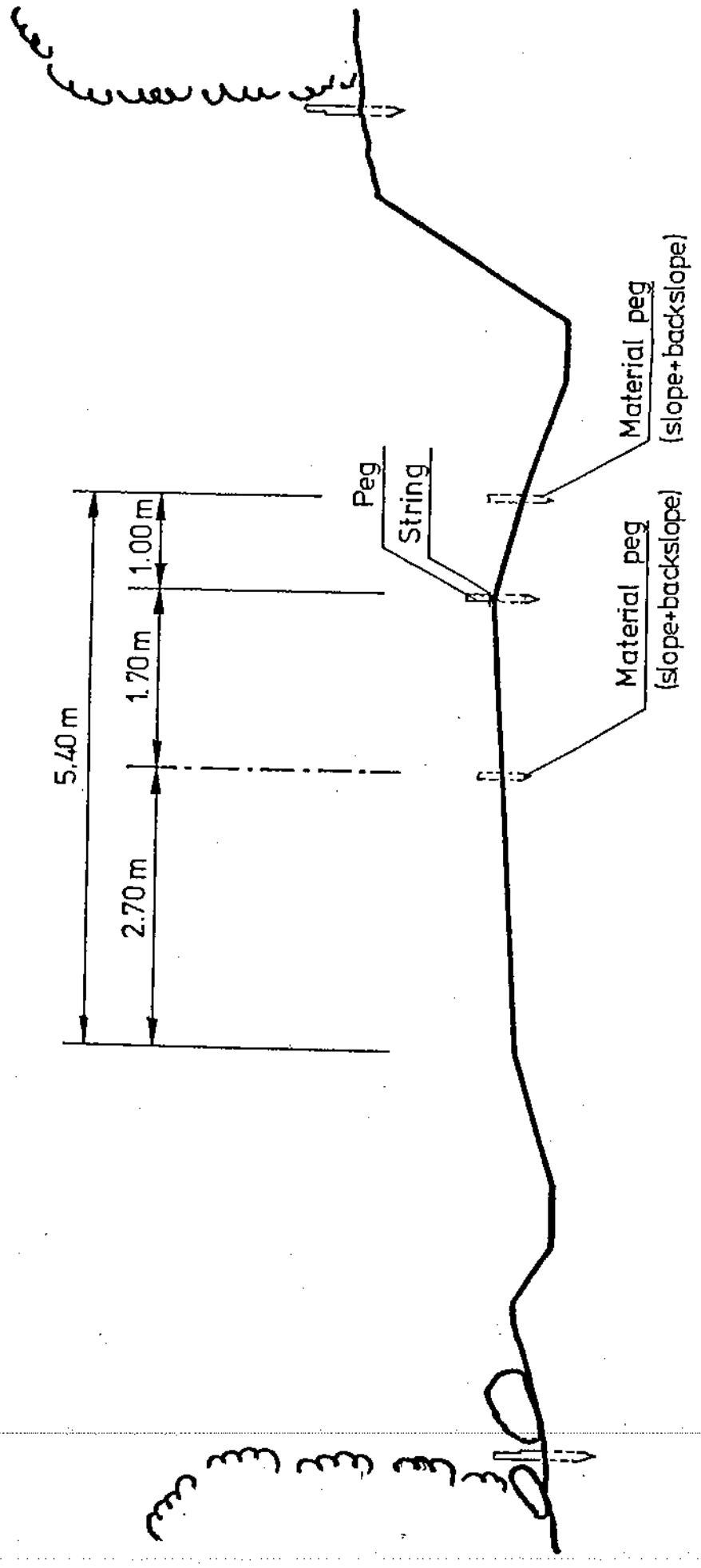


THIRD COMPACTION



BY HAND OR ANIMAL DRAWN ROLLER

SUPER ELEVATION



3.5.6 Mitre drains

The mitre drains (or turn out drains) lead away the water from the side drains away from the road to lower areas.

When possible, they should be placed at intervals of 20 metres. Remember the more mitre drains are installed, the less damage (either from scouring or silting) will occur. Wherever possible, the discharge water should be channelled to shamba bounderies in order to avoid damage to farm land. The minimum width of the mitre drains is 0.60m and they should have a gradient of 3-5%. The excavated soil is used to block the downhill side of the side ditch. Like any other trenches, the mitre drains are backsloped.

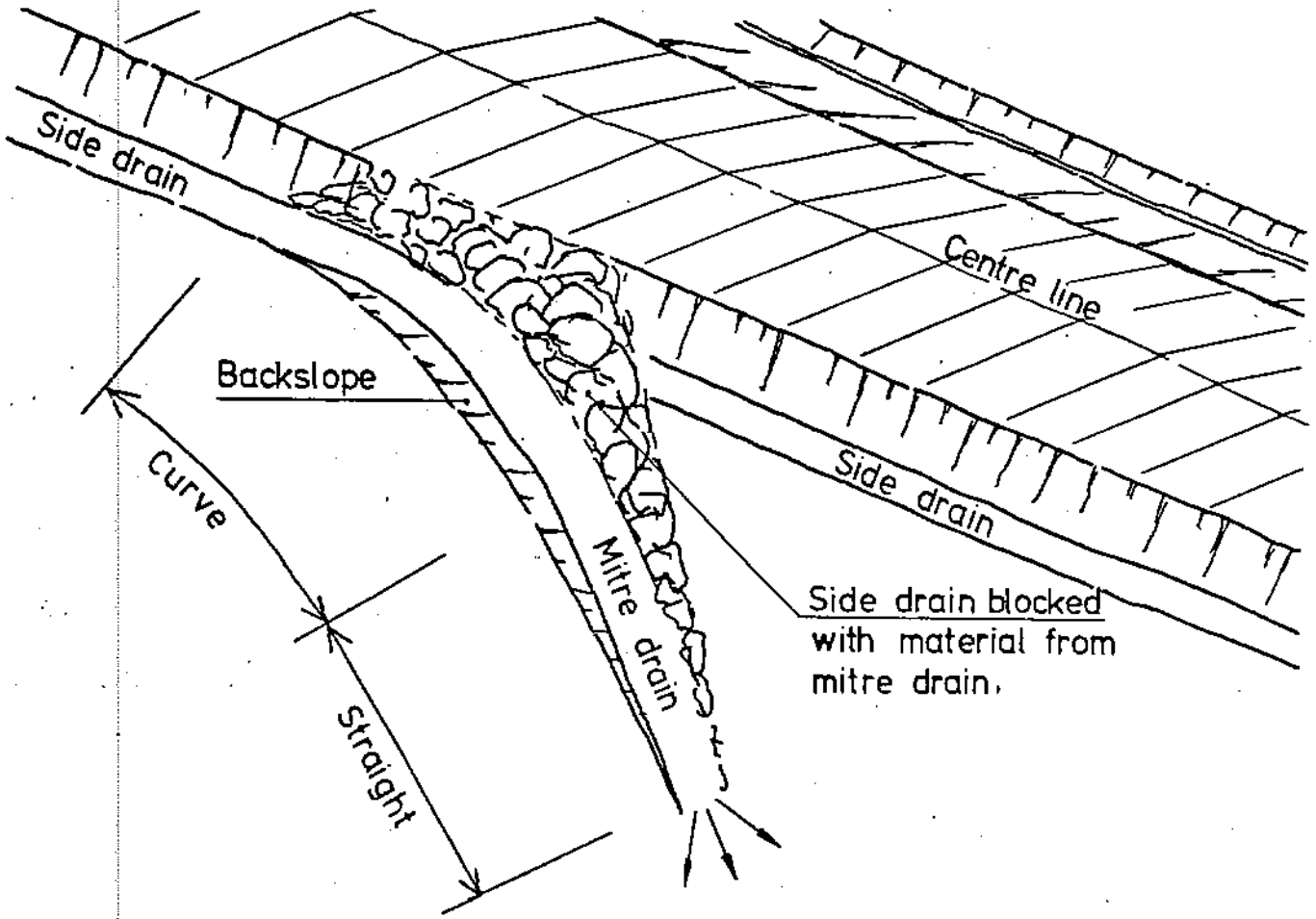
Tools: panga, slasher, jembe, mattock, pickaxe and shovel.

Taskrate: 3 - 4 m^3/manday

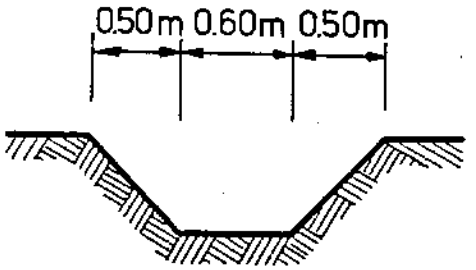
Check that:

- they are placed at the required intervals
- (in principle, the more mitre drains the better)
- the width is in minimum 0.60m;
- the mitre drains are constructed with a gradient of 3-5%, and at an angle of 60° with the centre-line of the road in the direction of the flow of surface run-off.

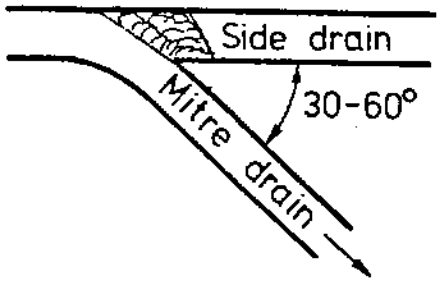
MITRE DRAINS



Cross section:



Angle:



- the side ditches are blocked on the downhill side;
- the mitre drain is backsloped;
- the mitre drain is straight;
- the mitre drain is leading to an open outlet and is not blocked by a hedge.

3.5.7. Scour checks

Where longitudinal gradients are steeper than 5%, the water gains high speed. Therefore, if no protective measures are taken, scouring is likely to occur. The simplest way of dealing with scouring is by reducing the volume of water (mitre drains at frequent intervals). Where this is not possible scour checks are constructed to reduce the velocity of the water. They hold back the silt carried by the water-flow and provide a series of stretches with gentle gradients interrupted by small "waterfalls".

Scour checks are usually constructed of natural stones or with wooden stakes. The level of the scour check must be in minimum 25cm below the edge of the carriageway in order to avoid the waterflow being diverted out of the sidedrains. The constructed scour checks have therefore to be controlled with the template. The interval at which scour checks are constructed depends on the gradient as shown below:-

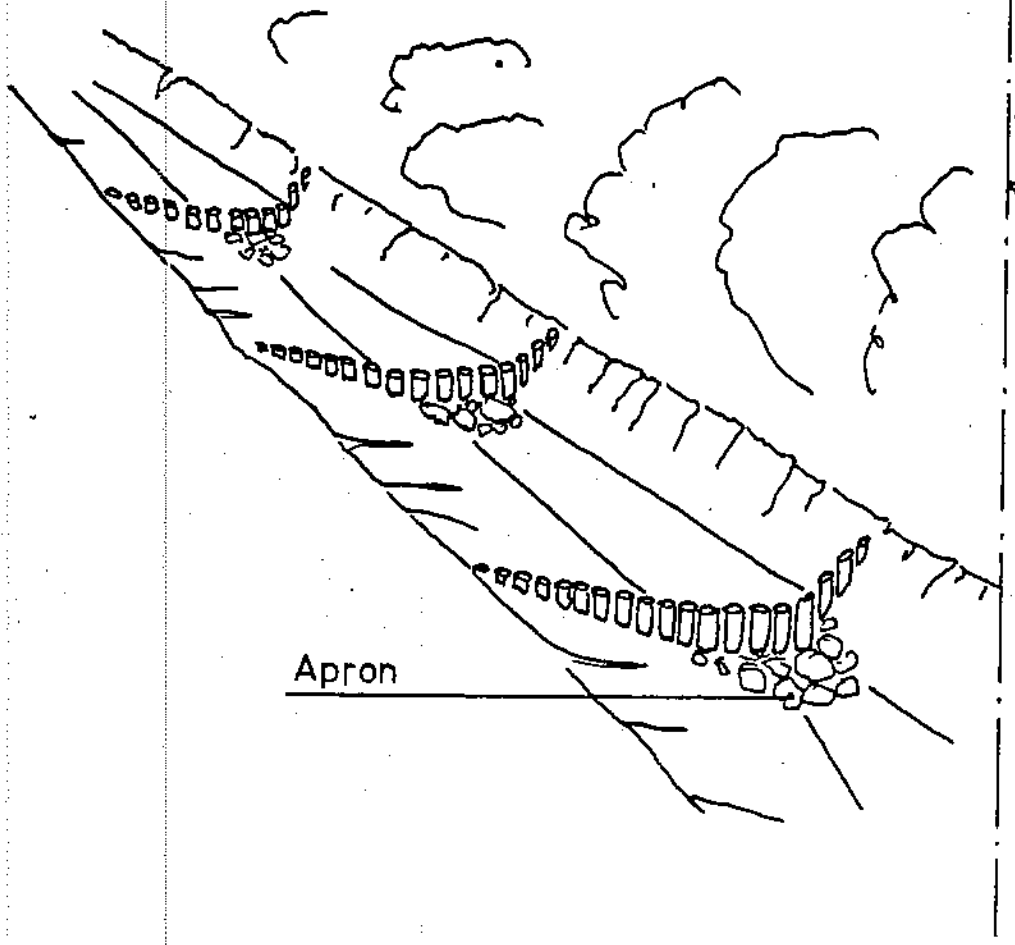
Gradient of road	Interval between	Remarks
4% or less	not required	would block the ditch!
5% 8%	30.0m 7.5m	no deepening of sid drains
10% 12%	5.0m 4.0m	side drains to be deepened

Note:

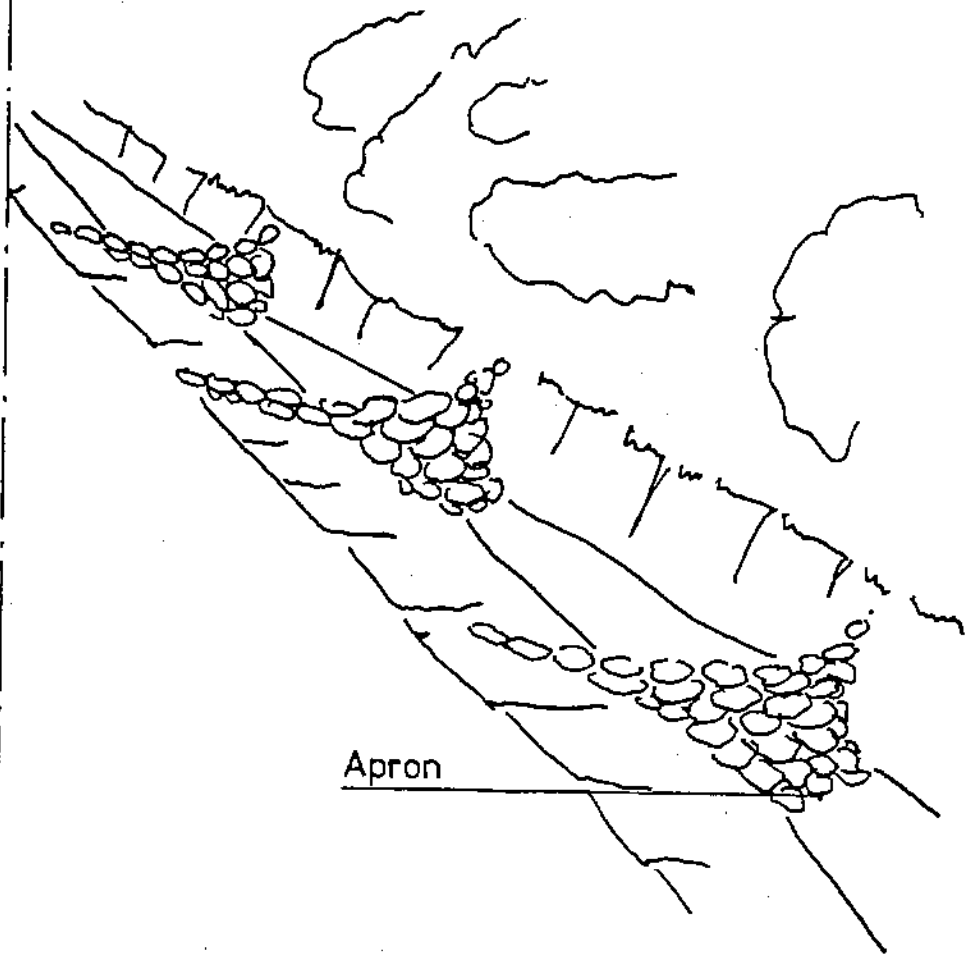
It is often found that, scour checks are constructed on roads with a gradient of less than 4%. This will cause more harm to the road than doing any good.

SCOUR CHECKS

Scour checks made of wooden stakes:



Scour checks made of stones:



The scour check will act as a blockage and will lead to a silting up of the side drains.

Tools: panga, saw, jembe (mattock,pickaxe in hard and stony soil) sledge hammer, wheelbarrow, tape measure, scour check template and spirit level.

Taskrate: 4 scour checks per manday. (This includes the preparation of the construction materials).

Check that:
- Scour checks are constructed where needed
- scour checks are constructed correctly at correct intervals;
- stakes are cut to correct length;
- stakes are hammered into the ground to the required depth;
- stones are placed stable in the ground;
- scour checks are wide enough;
- a scour check template is used;
- the level of the scour check is in minimum 25 cm below the edge of the carriageway.

3.5.8. Culverts

The culvert is a transversal drain built under the road and its function is to lead water from one side of the side ditch to the other, the latter being on the lower ground.

The culvert rings are usually of concrete and manufactured at the base camp. The most common diameter is 60cm (24") but for crossings with permanent waterflow or large volumes of water, culverts of 90cm (36") diameter are frequently used. Smaller diameters than 60cm are difficult to maintain and are easily blocked. The culvert rings are usually laid perpendicular to the centre line of the road. For MRP standard section eight rings will be needed per line.

The culvert bed has to be stable and at the correct level. If the natural material is not suitable, a bed of murram or concrete should be made.

Big stones might damage the pipes and must be removed. Large stones must not be allowed immediately under, against or over the concrete pipe as this will result in breakage when the culvert is fully loaded. The shape of the culvert bed is controlled with a culvert template. The overfill must be a minimum of three quarters of the culvert diameter. The gradient of a culvert depends on the terrain situation but to prevent silting up and erosion, the gradient should normally be kept between 2 and 5%. Culverts less than 60cm (24") diameter will not be used as they are very difficult to maintain. When frequent access is required across a side ditch the invert should be stoned to provide problem free passage of vehicles.

Tools:

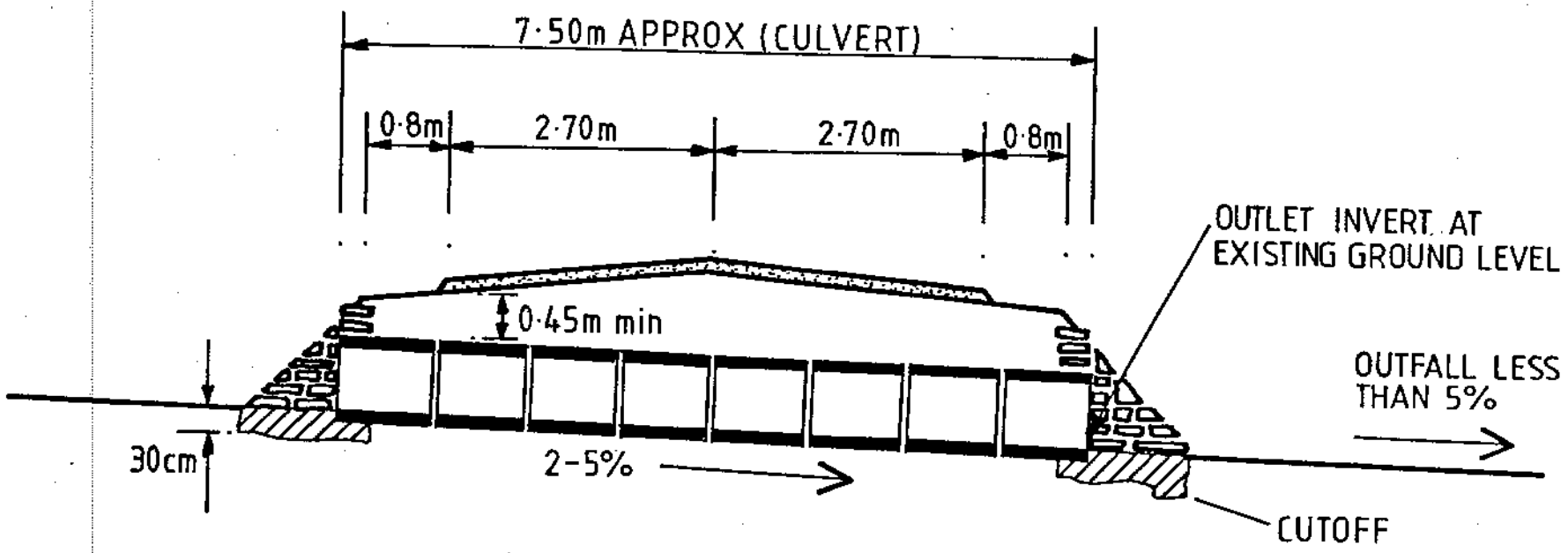
- tape measure, spirit level, straight edge (or line and level, boning rod) for setting out;
- jembe, (mattcok, pickaxe in hard or stony soil), shovel, wheelbarrow and culvert template for excavation of the trench.

Check that:

- Culvert is located and set out correctly
- outlet trench is straight
- outlet trench is backsloped and is minimum o.60m wide;
- the culvert bed is prepared in stable and suitable material;
- culvert bed and outlet have correct gradients.

CULVERT TYPE A : FLAT OUTFALL (<5%)

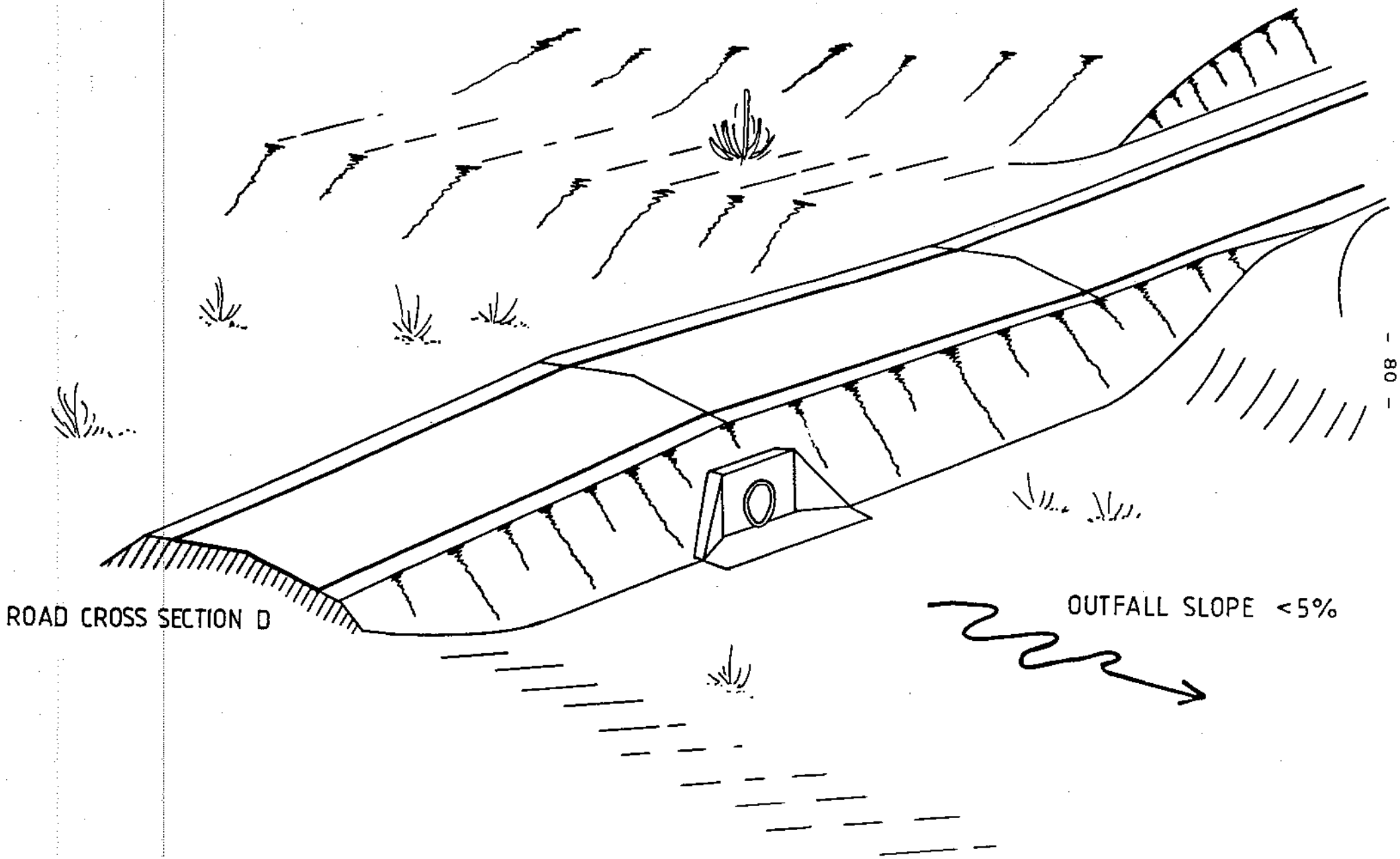
ROAD CROSS SECTION TYPE D



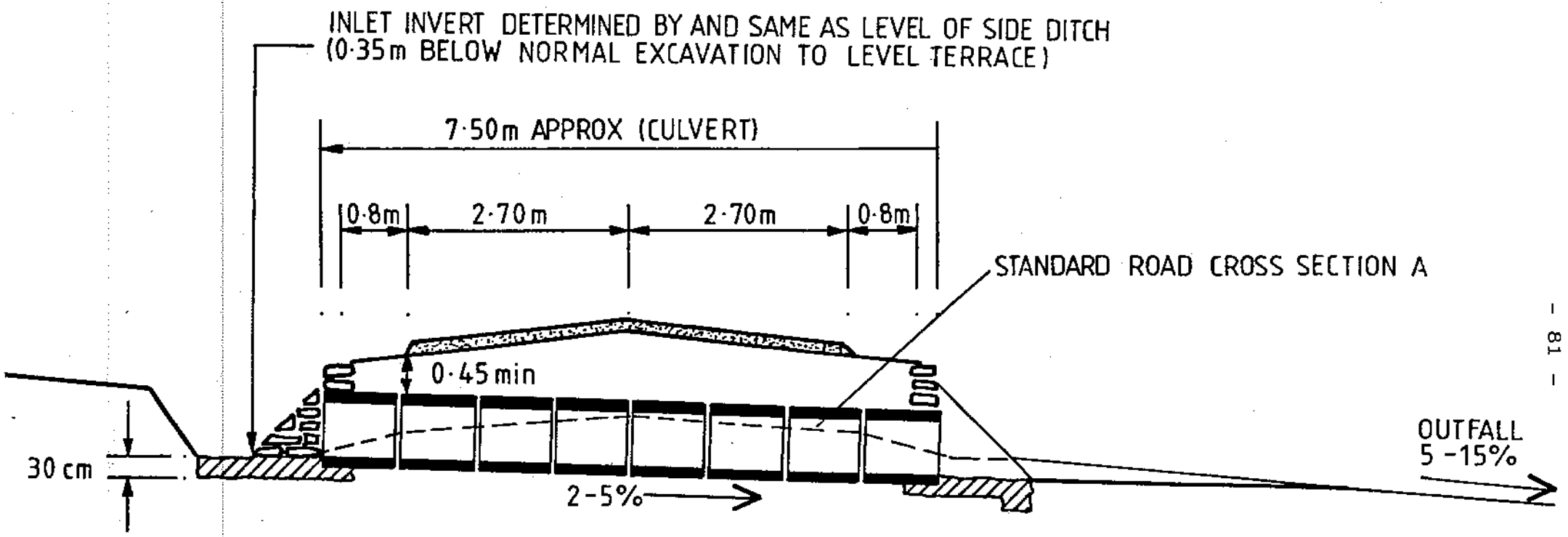
NOTES :

1. HEADWALLS, APRONS & CUTOFF IN MASONRY WITH CONCRETE/ MORTAR BEDDING.
2. HEADWALLS EQUIDISTANT FROM CENTRE LINE OF ROAD.
3. MINIMUM EARTHWORKS COVER TO CULVERT = 45cm on 60cm DIA. RINGS.
4. FILL MATERIAL COMPACTED IN 15cm LAYERS.
5. CULVERT RING JOINTS SEALED WITH 1:4 MORTAR.
6. 8 NO. STANDARD RINGS TO BE USED FOR VEHICLE SAFETY REASONS.
7. RAMP EITHER SIDE OF CULVERT MAXIMUM GRADIENT 5% (1 in 20)
8. CONCRETE OUTLET CUTOFF TO BE FOUNDED 0·7m BELOW GROUND LEVEL ON MAIN WATERCOURSES.

CULVERT TYPE A : FLAT OUTFALL



CULVERT TYPE B: INTERMEDIATE OUTFALL (5-15%)



NOTES:
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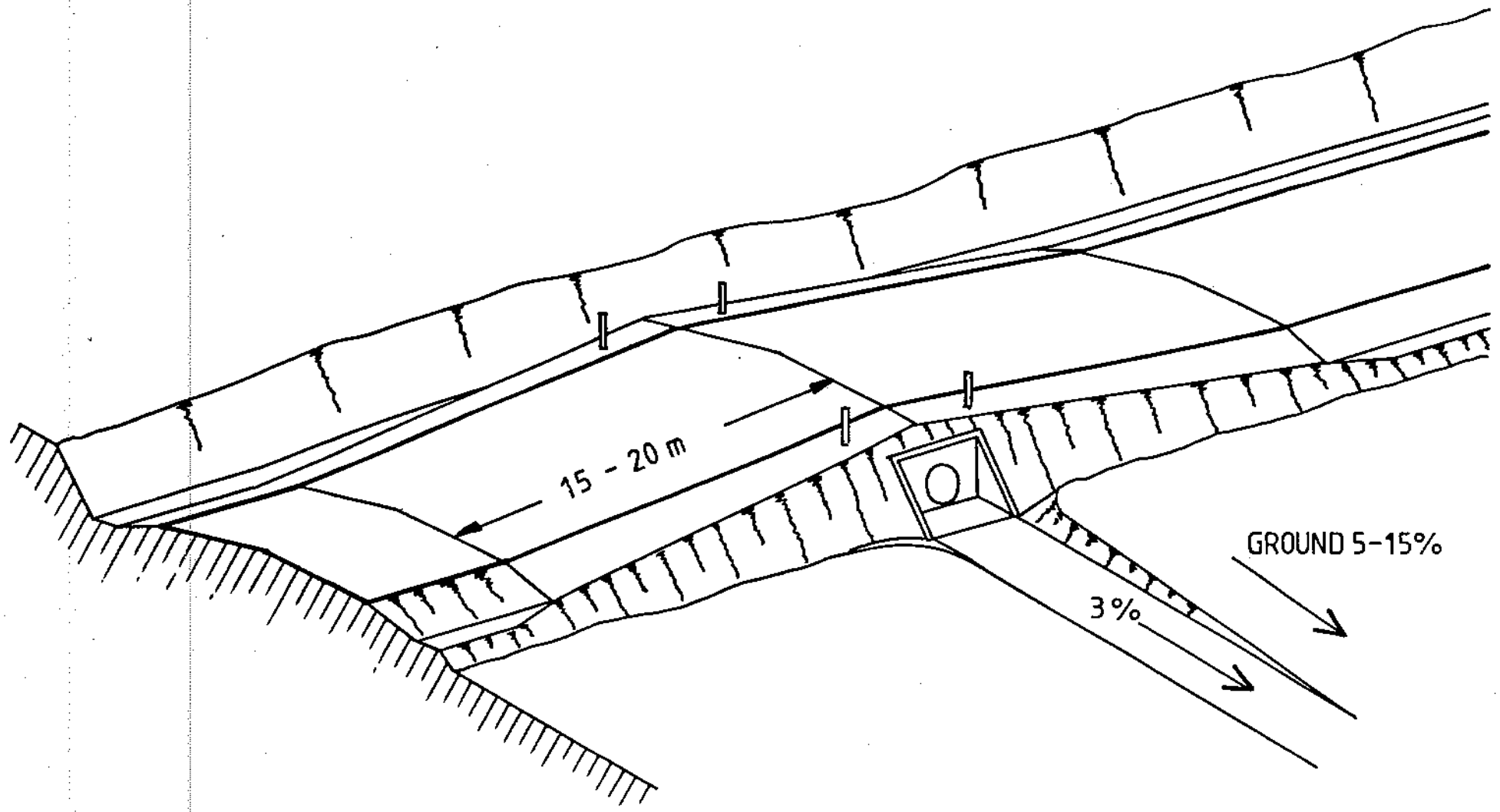
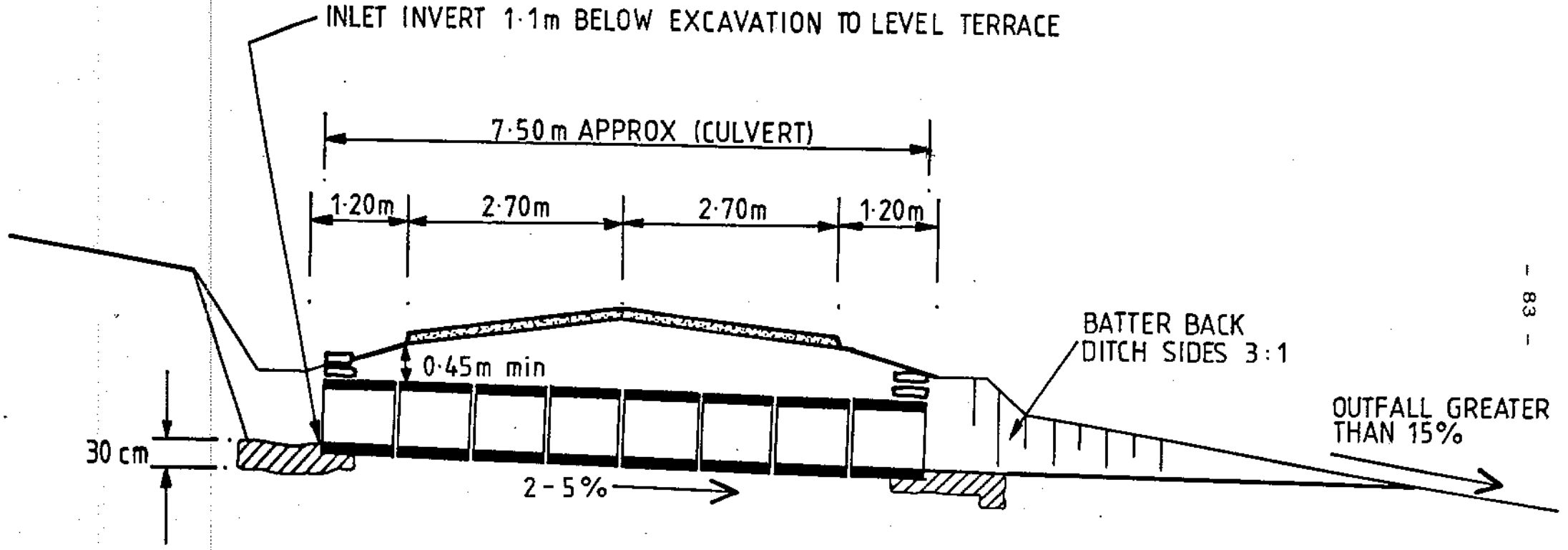
2. HEADWALLS EQUIDISTANT FROM CENTRE LINE OF ROAD.
3. MINIMUM EARTHWORTHS COVER TO CULVERT = 45 cm on 60 cm DIA. RINGS.
4. FILL MATERIAL COMPACTED IN 15 cm LAYERS.
5. CULVERT RING JOINTS SEALED WITH 1:4 MORTAR
6. 8 NO. STANDARD RINGS TO BE USED FOR VEHICLE SAFETY REASONS.
7. RAMP EITHER SIDE OF CULVERT MAXIMUM GRADIENT 5% (1 in 20).

CULVERT TYPE B: INTERMEDIATE OUTFALL

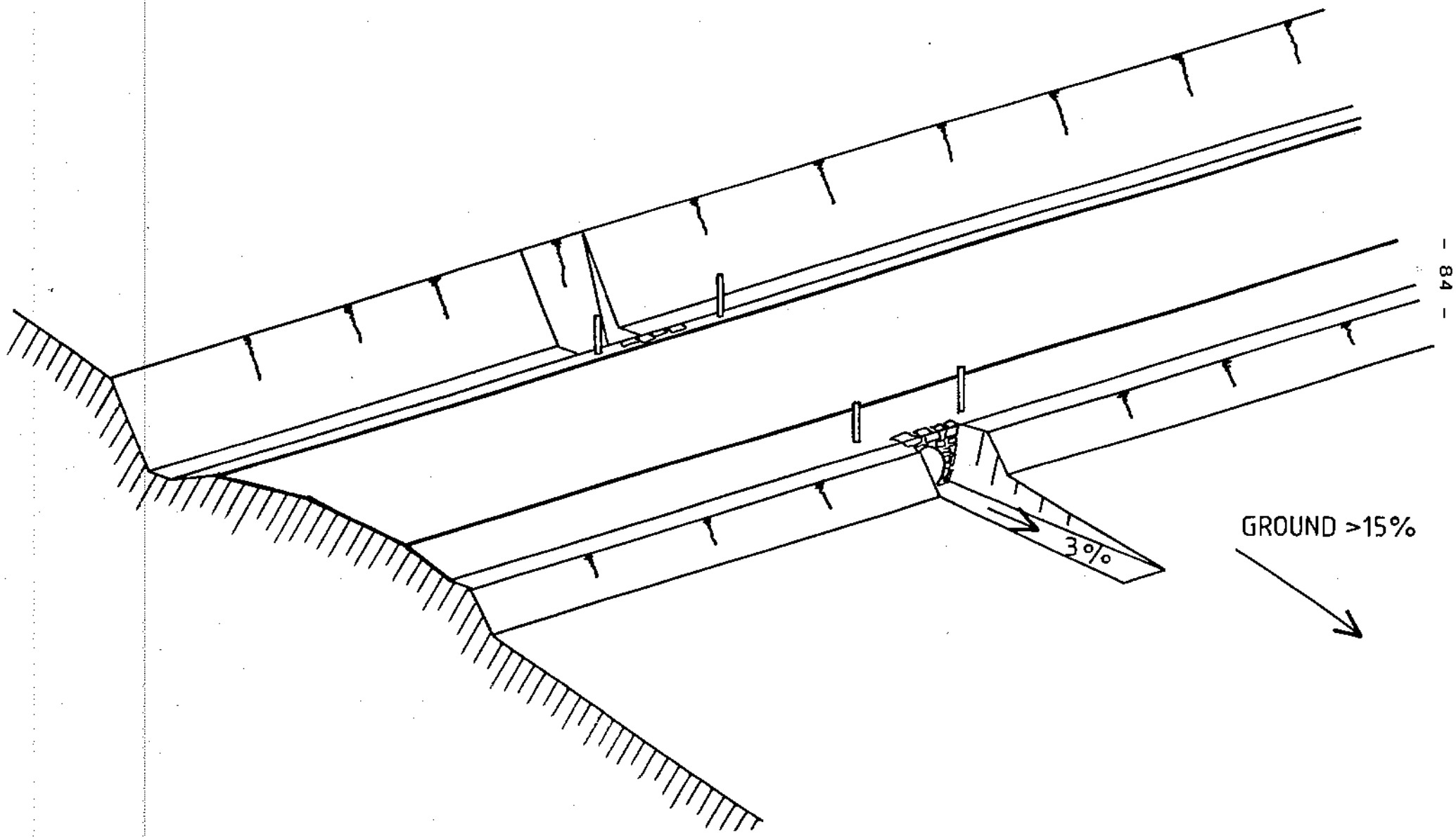


CULVERT TYPE C : STEEP OUTFALL (>15%)

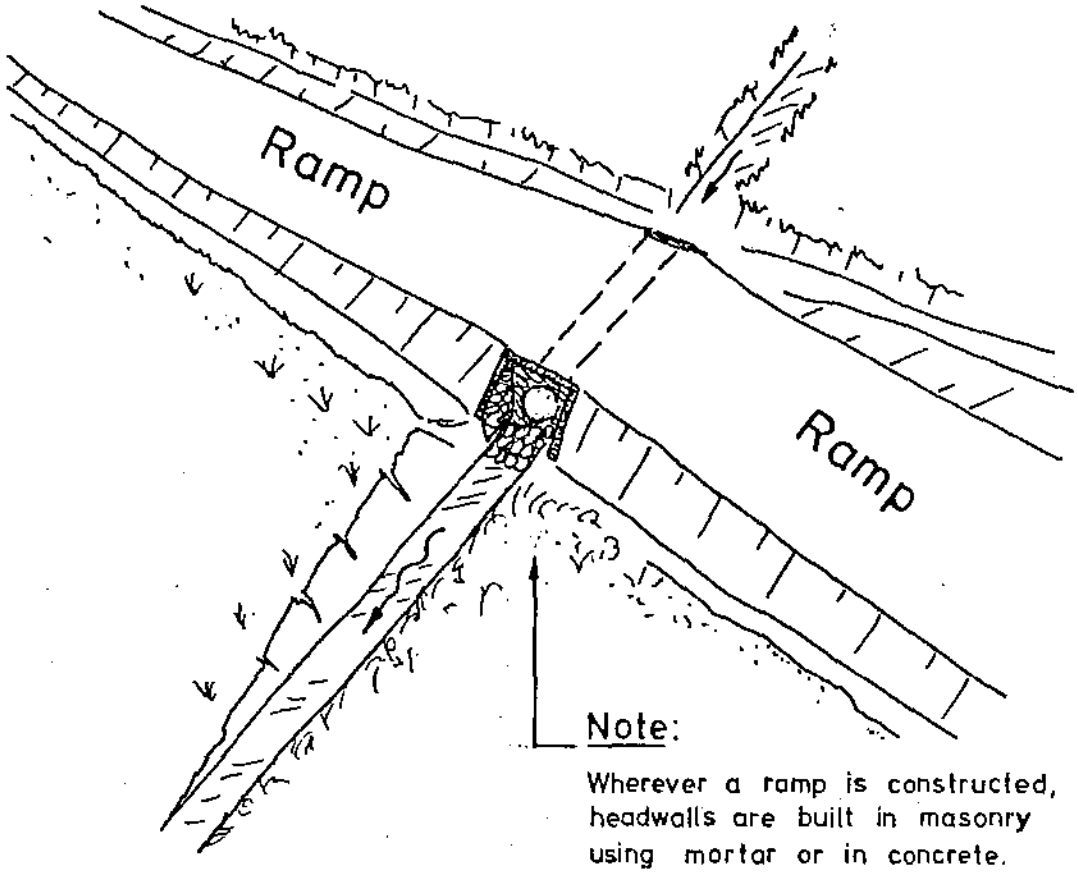


NOTES
1. HEADWALLS AND INLET RAMPS TO BE DRY MASONRY, APRONS AND CUT OFF TO BE MASONRY IN CONCRETE/MORTAR BEDDING.
2. HEADWALLS EQUIDISTANT FROM CENTRE LINE OF ROAD.
3. MINIMUM EARTHWORKS COVER TO CULVERT. = 45cm on 60cm DIA. RINGS.
4. FILL MATERIAL COMPACTED IN 15cm LAYERS.
5. CULVERT RING JOINTS SEALED WITH 1:4 MORTAR.
6. 8 NO. STANDARD RINGS TO BE USED FOR VEHICLE SAFETY REASONS.

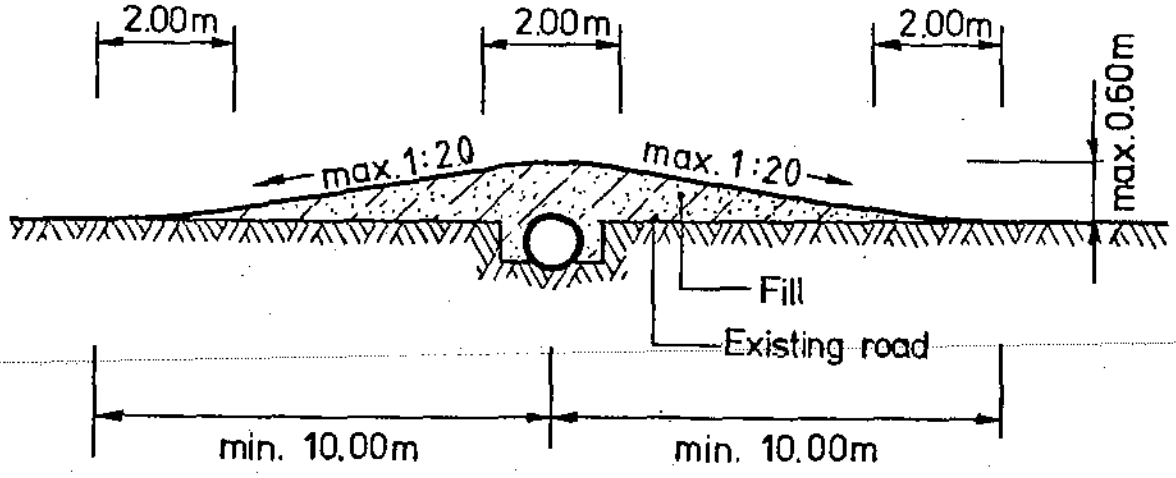
CULVERT TYPE C : STEEP OUTFALL



RAMP OVER CULVERT



Section :



CHAPTER 4.0: STRUCTURES

4.1 INTRODUCTION

Structures to be constructed or improved under the MRP will comprise bridges, box and pipe culverts, and drifts. On some of the Minor Roads, a number of these structures are existing and will only need minor improvement. However, where required structures are non-existent, they will be constructed in accordance with the MOTC Standard Manuals for bridges, culverts and drifts. The Field Supervisor will be expected to liaise with the structures sections at the Provincial Engineers offices with respect to matters related to structures.

The structures shall be constructed using locally available materials and shall be appropriate for the type of crossing and traffic. Due to the fast rotting of timber, no timber decked bridges will be newly constructed, instead concrete slabs will be constructed.

Structures to be undertaken on any particular road shall be considered during evaluation and their cost estimate be indicated in the evaluation report.

Construction of the structures shall, where possible be undertaken ahead of road construction activities in order to give access to transportation of materials during road construction.

4.2 MATERIALS

Outlined below are the materials which may be required for the construction of MRP structures:

Timber for shuttering
Stone (natural)
Cement
Sand
Aggregates (ballast or chippings)
Concrete Blocks
Culvert rings
Steel bars
Hard core

Timber

Sawn timber for shuttering will be available from local saw mills and will be procured from those who will be possessing Government Supply Contracts.

Stone

Shaped (or dressed) stone is a good material and is easy to use for abutments and wing walls where available. The dimensions vary but usually the height and width is around 23 cm (9") with a length of approximately 40 cm.

Natural (unshaped) stone will be used for head walls and wing walls or culverts, and for retaining walls for drifts. For load bearing walls (abutments) the stone shall usually be shaped.

Cement

The Portland Cement normally comes from Mombasa and is on the Government Supply Contracts.

Storage of cement shall be done in well-ventilated and water-tight stores.

Sand

Sand will often be found locally but care shall be taken so that it does not contain impurities.

Ballast

If suitable stone will be available, ballast down to 25 mm size can be had crushed, and is suitable for low and medium class concrete.

Workers with reasonable skill can crush something like 0.07 to 0.15m^3 (loose) of 25-30mm ballast per day, giving costs in the order of 150 Kshs/m^3 (loose) (including extraction of stones and knapping)

Otherwise, ballast will be procured from local suppliers who possess Government Supply Contracts.

Concrete blocks

Concrete blocks will be bought locally if required. However, shaped building stones which are stronger will be prefered.

Culvert rings

Culvert rings shall be manufactured within the unit. The Ø 60cm (24") is the most frequently used dimension in single line culverts but for bigger culverts Ø 90cm (36") is manufactured.

Steel bars

Steel bars required as reinforcement for structures will be procured from suppliers with Government Contracts.

4.3 BRIDGES

Bridges are comparatively expensive and shall be limited usually to not more than 10m span. Before deciding to build a bridge the other alternative structures such as culverts and drifts, shall be considered with regard to water flow, passability during the year, expected traffic flow and locally available materials and cost.

Foundation and Abutments

Foundations and abutments shall be designed specially for each bridge on the soil conditions, height of abutments and available materials.

The most common type of material for the foundation is concrete/stone while for the abutments shaped stone or concrete blocks are the most common.

Girders

Precast concrete beams will be manufactured using the facilities of the Provincial Bridge units. Normally these units have steel shutters for casting of appropriate beams.

Decking

Decking will be provided through the construction of a concrete slab over the concrete beams.

4.4. DRIFTS

The drift shall basically be an improved ford. They shall be used in crossing rivers or streams which are dry or have very small water flows most of the year but for a short period have water levels which suddenly becomes very high.

The simple drifts of pitched stone,without concrete, but with a downstream retaining wall and an apron have proved satisfactory and will be installed when necessary. A downstream 'cut off' is essential.

The drifts, as well as other structures, shall require constant maintenance and repair. In the case of drifts, scouring shall be controlled immediately and sand which become deposited on the drifts shall be removed. The approaches shall also be properly maintained.

In exceptional cases vented drifts, i.e. a drift with built-in culverts shall be used but their need will be justified by the amount of water flow.

The selection of suitable drift sites will be done after the following general points have been considered:-

a) The course of the river shall not be likely to change at the drift site under consideration

over the next few years (check for sign of recent changes in the course)

b) The sub-soil bearing capacity must be such that it can carry the load of the traffic and the drift structure.

c) The location of the drift shall be on a straight stretch of the river and shall never be on or immediately after a river bend.

4.5 MULTIPLE CULVERT LINES

Multiple culvert lines Ø 90cm (36") rings will be used in crossings of the streams with a relatively constant water flow. Wing walls of stone masonry as well as aprons will be constructed.

If the stream is likely to flood the vented drift can then be considered.

4.6 BOX CULVERT

Box culvert will be constructed where the pipe culverts will be considered inadequate and where bridges would be unnecessary.

4.7 SUPERVISION AND REPORTING

The supervision of the major structures (bridges, Drifts, pipes and box culverts) shall be done directly by the Engineer.

The Engineer and the Officer-in-charge shall visit the river crossing and decide on the crossing site and the most suitable type of structure.

The Engineer will then calculate the cost estimate for the structure, purchase and deliver all the necessary materials. There shall be a structural overseer to carry out daily works with very close supervision from the Officer-in-charge and the Engineer. All the instructions from the Engineer shall be in writing and the overseer

shall be provided with drawings showing all parts and dimensions of the structure.

All the information about the structure with respect to the type of material used and their cost shall be properly recorded and filed.

CHAPTER 5.0 : CONCRETE TECHNOLOGY AND MANUFACTURING OF CONCRETE RINGS

5.1 INTRODUCTION

The use of concrete in MRP will be generally limited to fabrication of culvert rings, culverts' floors, foundation and slabs of box-culverts and bridges. Concrete will also be used in the construction of base-camps.

5.2 CONCRETE TECHNOLOGY

Concrete is a mixture of

Aggregate + Adhesive + Water

usually Gravel and Sand + Cement + Water

Through the hardening process of adhesives and water a stiff plastic mixture of gravel/sand, cement and water, becomes a strong, solid material after some time. (Setting time: 1/2 to 1 hour, hardening time: 2 to 12 hours, **getting final strength after 28 days).**

5.3 Types of Concrete according to their use

- Lean concrete(class P) mix 1:4:8, is a meagre, stiff (not too wet) mixture used for blinding culvert beds and fills.

- Mass concrete (class4) mix 1:3:6, is a stiff mixture with coarse aggregates upto 40 - 50 mm in size, used for gravity non-reinforced structures.

- Reinforced concrete (class 20) mix 1:2:4, (and class 25) mix 1:1,5:3.
  The concrete is a medium mixture with a high amou of cement and aggregates upto 40mm for light reinforced structures, upto 20mm for heavy reinforced structures.

5.4 The Aggregates

SAND : Stone grains upto 5 mm – fine aggregate
GRAVEL : Stone grains more than 5mm-Coarse aggregate

5.4.1 Impurities

If aggregates are dirty and contain grass, leaves, wood, humus, silt, clay etc. they have to be washed, but attention has to be paid to not washing off the fine sand aggregate. Gravel and sand containing impurities cause marked loss of strength of the finished concrete. Simple test (bottle test) to determine the amount of impurities can be carried out in the field. Aggregates should not contain more than 6% dirt.

5.4.2 Grading of Aggregates

Volume batching is allowed for concrete work like blinding, pipe culvert beds, culvert headwalls, drifts and other not very heavily reinforced minor works. When aggregates are batched by volume, the approval of the Engineer shall first be obtained, and approved gauge boxes have to be used.

The most common ratios of batched aggregates are:

1 part of fine to 2 parts of coarse

or

2 parts of fine to 3 parts of coarse.

5.5 Adhesives

The cement used is Portland Cement, which is made from a mixture of lime-containing material (generally chalk or limestone) and clayey material (generally clay).

Cement is powerless to set until moisture is added to it. Then a chemical action takes place which causes the particles to bind together in a solid mass. Therefore cement must be kept dry, for even the moisture in the atmosphere is sufficient to start the setting action.

5.5.1 Storage of cement

Cement is expensive and therefore it has to be handled carefully. Cement is usually in bags which have to be unloaded by hand in order to keep the paper bags unbroken. Since it hardens if in touch with water or humidity close attention has to be paid to its storage.

Hardened pieces found when opening the bag have to be removed by sieving the cement. If they remain inside the batch, the strength of the finished concrete will be reduced.

5.5.2 The amount of cement

In batching and mixing concrete, cement is always measured in kg (or in bags, one bag always weights 50 kg).

The QUALITY OF THE FINISHED CONCRETE is influenced by the amount of cement. Within limits, the higher this proportion is, the stronger is the concrete. But other factors also influence the quality:

- The quality and properties of the aggregates used.
- The strength of the cement paste. The wetter the mixture the weaker the concrete so long as the amount of cement is not altered.
- The even distribution of different sized particles of aggregates and of the cement paste. This will make an easily workable mixture with less water, or, in other words a stronger cement paste.

5.6 WATER

5.6.1 Quality of mixing water

Mixing water must be clean. It can be taken from rivers, lakes and wells. Surface run off, waste and salt water should not be used for mixing. Dirty water should be stored in drums and allowed to settle before the top water can be used.

5.6.2 Water-cement ratio

The amount of water used in mixing has a great influence on the later density and compressive strength of the consolidated concrete. The wetter the mix, the weaker the consolidated concrete is. The amount of water used should be the minimum necessary to give sufficient workability for efficient consolidation of the concrete. For concrete placed by hand, the water content is usually between 23 litres and 27 litres per bag of cement, depending on the type of aggregate and the proportions of the mix.

When using mechanical plant (mixing and compacting) the amount of mixing water can be lowered to about 20 litres per bag of cement.

The term 'WORKABILITY" is used to describe the ease with which the concrete can be placed and consolidated without segregation or separation of the individual materials.

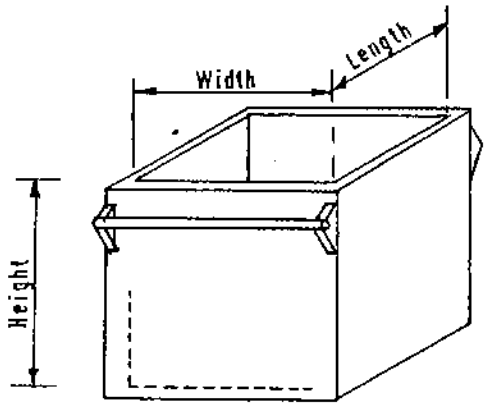
The quantity of water used for each class of concrete shall be just sufficient to produce a dense concrete of adequate strength and workability for its purpose.

5.7 MIXING OF CONCRETE

APPROXIMATE TABLE FOR BATCHING BY VOLUME

Concrete Class	Nominal mix by volume	Batch with 1 bag of cement			Material required for 1 cubic metre o finished concrete (approx)		
		Number of Boxes of Aggregates		Approx. yield per batch	Cement in bags (kg)	Fine (m^3)	Cours (m^3)
		Fine	Course				
P	1:4:8 (40mm)	4	8	0.30m^3	3.3 (166kg)	0.47	0.94
Q	1:3:6 (40mm)	3	6	0.24m^3	4.3 (215kg)	0.46	0.92
20	1:2:4(20mm) + 40mm)	2	4	0.165m^3	6 (300kg)	0.42	0.84
25	1:1.5:3 (20mm)	1.5	3	0.14	7.3 (365kg)	0.38	0.76

Concrete Classes P,Q,20 and 25 can be batched by volume. Gauge Boxes are used for this.



Box dimensions

Inside measurements

Length	Width	Height
400 mm	300 mm	300 mm

Volume

0.036 m^3 or 36 litres.

36 litres are equal to 1 bag of cement.

Concrete Classes 30 and 40 have to be measured by weight.

When batching concrete the correct proportions of cement, sand and coarse aggregate must be maintained throughout.

If the sand is damp (moisture can amount to upto 25% of the volume) then the added water quantity will need to be reduced.

5.8 Mixing of Concrete by hand

This does not need much equipment but a lot of manpower which is one of the main objectives of MRP; to create employment. Concrete should never be mixed on soil. A platform will be built, with boards, metal sheets or concrete. It will be level to prevent water or liquid material from flowing off the platform. The size of the platform will be such that a continuous mixing process is possible. (E.g. 4 x 6 metres).

5.8.1 Procedure for Mixing

A batch to be hand mixed should not be larger than $0.5m^3$. The following method of mixing will be adopted.

a) Measure the amount of aggregate used for the batch put it onto the platform in layers and mix it thoroughly. Add cement. If the batch is a big one put aggregate and cement in alternate layers. Form the material into a pile.

b) Two men should face each other from opposite sides of the pile, working from the outside to the centre, turning the material from one heap to another at least twice until it is uniform in colour.

c) When adding water, the material is sprinkled gradually while it is turned over another 3 times that is until it is uniform in consistency and sufficiently workable. Not more than 25 litres of water per bag of cement should be added.

5.8.2 Transporting Concrete

Concrete should be mixed as near as possible to the site of placement. Transporting concrete shall be done with wheelbarrow. Time taken for transporting it should be such that the concrete will not harden before reaching the site of placement.

5.9 Placing of Concrete

Important: Before concrete is placed the forms or shutters must be cleaned of all rubbish. The forms should be dampened the day before and again before the work starts, if they have not been oiled. Concrete has to be placed in such a way that it can be vibrated or rammed immediately after, and placing continues without disturbance.

If the concrete is shovelled for any distance, segregation takes place and thin reinforcement bars will be deformed, therefore it is better to transport the concrete as near as possible to where it has to be poured.

In placing concrete into wall or column forms it is advisable to take a funnel (constructed with timber) to prevent wastage of the concrete which would fall outside the form. The concrete has to be placed in layers not higher than 300mm when hand rammed and not higher than 600mm when vibrated with a poker vibrator.

Pouring in layers is correct whereas pouring heaps causes segregation.

Pouring concrete for slabs has to be done at once for the whole height of the slab so that the reinforcement bars are covered completely.

Pouring must be organized in such a way that previous and successive pours can be vibrated into each other before setting has started to take place.

5.10 Curing of concrete

Concrete hardens as a result of the hydration of cement and water. Fresh concrete contains more than enough water to hydrate the cement completely but if the concrete is not protected against drying out the water content, especially near the surface, will drop below the amount required for complete hydration. As a result there will be cracks all over the surface.

The more water and cement used, the more the concrete shrinks

The procedure called curing is designed to prevent surface evaporation of water during the setting and hardening stage. Curing should start as soon as possible without damaging the surface. Curing is brought about by keeping the concrete surface continuously wet.

Depending upon the structure and the means available this may be done by:

- sprinkling or flooding
- Covering with empty cement bags, sand, sawdust (minimum coverage 50mm), grass and leaves which should be dampened from time to time.
- wood forms left in place also furnish good protection if they are loosened and flooded with water at frequent intervals.

ANY CONCRETE STRUCTURE HAS TO BE CURED FOR AT LEAST 7 DAYS

5.11 CASTING CULVERTS

Although the culvert cost is only a very small part of the total cost of the road, the importance of the culvert in the drainage system is very great. Therefore it must be ensured that their manufacture keeps up with the demand and that the quality of the rings is acceptable.

The rings are cast locally, using steel moulds and no reinforcement is used. The most common size is the Ø 60 cm (24") pipe although Ø 45 cm (18") and Ø 90 cm (36") is sometimes used. Ø 30 cm (12") are of little use since they are easily blocked. Since the difference in cost between a Ø 60 cm and a Ø 45 cm pipe is small, it is recommended that Ø 60 cm is used as the standard size.

The casting of culverts is done within the units at suitable sites where ballast, sand and water is available.

A skilled headman or 'fundi' should be in charge of the casting site, which for 15 moulds will have some 4-6 skilled labourers.

In order to maintain a high quality, the general guidelines for concrete technology (see F.1) and the following, more specific, guidelines should be followed.

5.12 Selecting Manufacturing Place

The manufacturing site should be chosen after considering the cost (availability) of the materials (cement, sand, ballast and water) on site and the distribution of the roads to be served from that culvert factory.

There must be ample space for storing (and curing) of culverts, bearing in mind that the fresh culverts should not be moved until after one week

5.13 Pouring

The pouring of the concrete into the moulds must be done within 15 minutes of mixing.

Before starting to pour the concrete, it must be ensured that the moulds are correctly centred and properly oilded.

The concrete can be transported in buckets from the mixed batch to the moulds. To simplify the pouring and minimize waste, a karai of suitable size can be placed upside down over the inner mould. The conrete should then be heaped on the karai and evenly distributed into the mould.

The concrete should be compacted by tampering with a narrow reinforcement rod and by carefully pounding the moulds with wooden hammers.

5.14 Stripping and curing

The moulds should not be removed before the second day after the pouring, and the stripping should be done very carefully to avoid damage to the fresh rings.

The fresh rings must not be moved until after one week and they must be kept wet and protected from direct sunshine during at least the first week. This can be done by covering the rings with sacks or banana leaves which are then sprinkled with water from time to time.

Allow at least 3 weeks storing before the rings are transported to the construction sites.

5.15 Loading, transport and off-loading of culvert rings

Loading shall be done by rolling the rings onto the vehicle, (if the casting site is permanent, an earthramp can be constructed for this purpose).

The ring should be transported standing in a 10-20 cm layer or sand (or sawdust) and any empty space between rings filled with old car tyres etc. to prevent the rings from tipping over.

CHAPTER 6.0: GRAVELLING IN MRP

6.1 INTRODUCTION

MRP units shall have 2 gravelling sites called sub-units and one quarry preparation site. The gravelling operation in MRP will be organized and executed along almost similar lines to RARP. The gravelling sub-units will therefore be equiped with farm tractors and single axle trailers for hauling of gravel surfacing material. However, the method of gravelling and the quipment will be adqpted to meet the needs of the different conditions of MRP.

It is expected that the gravelling of a road will commence immediately after the road is improved to completion and compacted with a deadweight roller. Where immediate compaction of a road will not be applicable, the gravelling operation will be delayed for at least 3 months in order to allow the natural consolidation of the earthworks to take place.

In those districts where average hauling distance for gravel exceed 10 kilometres, it is recommended that the gravelling by tractors and trailers be supplemented by gravelling with tippers, borrowed from the district Engineer or by a hauling contract.

6.2 RESOURCES

The responsibilities of the various personnel to be involved in the gravelling works is as follows:-

Engineer

The Engineer will have the ultimate responsibility for the gravelling of roads within all his units.

Officer-in-charge

The Officer-in-charge of the unit will have direct responsibility for the gravelling operation. He will supervise the works as well as the supporting repairs of the equipment on site.

Overseer

Under the Officer-in-charge and directly in charge of the daily work on each gravelling sub-unit site will be an Overseer. There will be another Overseer in charge of the quarry preparation. The Overseer shall have completed the gravelling training courses so that he will be equiped with the knowledge of how to supervise tractors, operators, storekeeper, and headmen. He shall also have the knowledge of planning and controlling the quality of the gravelling works.

Drivers (Operators)

Tractor drivers will be responsible for their equipment i.e. one tractor and two trailers. They will ensure that the equipment is handled and kept in good working order and reach the production targets set by the OiC and gravelling overseer.

Mechanics

Mechanics will be responsible for the minor repairs and service of the unit's vehicles including, and in particular the tractors and trailers for gravelling operations. When necessary, the Mechanics will carry out the minor repairs on the site.

Casual Labourers

The number of labourers will depend on the hauling distance and number of tractors and trailers deployed at a given time.

Headmen

The headmen will be nominated from the labourers employed. A headman shall be incharge of one gravelling activity.

Store keeper

The site store keeper shall be a casual employee, preferably a Form Four school leaver and be capable of keeping records.

Watchmen

Watchmen shall be casual employees and their actual number will depend on site conditions.

6.3 TOOLS

The tools used in the gravelling sub-unit will be of the same standard and quality as those used on construction sites. They shall be specially appropriate for labour-intensive road construction and gravelling.

The following tools shall normally be kept on site for each sub-unit.

Shovels	50	Pangas	10
Mattocks	50	Spreaders	30
Pick axes	50	Sledges hammers	3
Crow bars	10	Camber board	1
Jembes	20	Pegs	-
Strings	-	Spirit level	2

The tools will be issued every morning. They shall be returned in the store by the workers after they have used them.

6.4 EQUIPMENT

Equipment on each gravelling sub-unit site under the responsibility of an Overseer shall consist of:-

a) 3 Trailers
b) 6 Tractors
c) 1 Fuel Bowser (or shared by 2 sub-units)
d) 1 Water bowser (or shared by 2 sub-units)

The tractors will preferably have a capacity of 60HP. The trailers shall be specially designed for MRP gravelling with a $4m^3$ capacity. One tractor and one trailer will be available as spare for each Improvement Unit (2 sub-units)

The trailers shall not be of tipping type, but shall be off-loaded by hand.

The fuel bowser shall be used to supply and store fuel for tractors.

As the water consumption on a gravelling site is higher than on a construction site because of equipment, a water bowser which can be towed by a tractor will be made available on a gravelling site.

It is envisaged that the 2 gravelling sub-units will be operating on the same or adjacent roads probably sharing the same camp. This camp will be provided with the mechanic and shall be equiped with the following repair tools.

a)	Hydraulic jack, 7 tons capacity	1
b)	Tyre levers	4
c)	Wheel brace	1
d)	Foot pumps or engine operated pressure pumps	2
e)	Funnels each for oil and diesel	2
f)	Fully equiped toll box for tractors minor repairs	1
g)	Set of welding gas jars	1

The following spare parts shall always be stored in a gravelling site store:-

a)	Wheel nuts	20
b)	Complete spare wheel for trailers	2
c)	Patching set	1
d)	Spare tubes	2
e)	Fuel and oil filters	5 for each
f)	Any other consumable spare parts.	

Minor services and repairs shall be done by the mechanics on the site. Any major repair shall be supervised by an experienced mechanic from the base camp.

The following fuel, oils and lubricants shall be stored on site camp:-

a) Diesel fuel
b) Engine oil
c) Gearbox oil
d) Differential oil
e) Hydraulic oil

All fuel, oil and lubricants used shall be measured and recorded on the work tickets and in the stores on the site book.

6.5 PLANNING

The Engineer shall identify the need for gravelling of a road and the source of gravel before its improvement commences and prepares a work-plan for gravelling it.

The following procedure may be used in the work-plan:-

1. Excavate trials pits at each quarry site to ascertain the gravel quality, extent (thickness) and overburden.

2. Select the quarry (quarries) and measure the haul distances. To shorten the haul distance select several quarries along the road if it is possible.

3. Decide whether the total length has to be gravelled. If not note lengths to be gravelled.

4. Draw a sketch showing the quarry, the access and the road to be gravelled. Note that state of the access to quarry (good or poor) and the quality of the material.

5. Determine the thickness of gravel to be laid and the number of layers on each section of road.

6. Calculate the length of the road to be gravelled within each haul-distance and fill in planning form. If two of more quarries are to be used, use one form for each quarry.

6.6 SUPERVISION AND REPORTING

A gravelling site need very close supervision by the Engineer and the Officer-in-charge.

The Engineer shall visit the gravelling sites at least once in every week and spend as much time as possible. He shall be accompanied by the Officer-in-charge during his visits and all his instructions to be Officer-in-charge and the Overseer shall be put down in writing to both of them.

The Engineer shall approve the quality of materials before excavation. The Engineer shall also be satisfied that the excavation of the materials is economical depending on the overburden, quantity etc.

During the inspection tours by the Engineer and/or Officer-in-charge they will check on the following:-

1. Mechanical condition of the tractors and trailers shall be checked thoroughly e.g.
   a) Hydraulic leakage on tractors
   b) Loose bolts on tractors and trailers
   c) Body condition of tractors and trailers
   d) Condition of tyres for tractors and trailers
   e) Trailer axles and chassis.

2. The Engineer shall check on the task rates and production depending on:-

   a) Number of tractors
   b) Haulage distance
   c) Availability of casual labourers.

3. The Engineer shall check on quarry organisation. a disorganised quarry lead to low task rates, low production and idle time by tractors.

During selection of quarry the Engineer shall consider the following main aspects:-

a) Quality
b) Quantity
c) Overburden
d) Hauling distance
e) State of access to quarry.

Quarries which are located in low-lying areas shall be avoided because they would be filled with water during the wet season.

a) Quality

When gravelling the road, note shall be taken of the quality of the material being excavated. It is a waste of money and time to surface a road with sub-standard material.

b) Quantity

Quantity of gravel material shall be assessed by digging one metre deep trial holes at intervals of about 10m. This will give the idea of how deep and how far the material has spread. It is uneconomical to work small and shallow quarries.

c) Overburden

A quarry with a higher amount of overburden than 0.3m depth shall not be excavated if the depth of the gravel materials is not more than 0.8m. That means the higher the amount of overburden, the deeper the amount of gravel should be. It is uneconomical to remove overburden of more than 0.3m depth to excavate gravel of say 0.4m depth.

d) Hauling Distance

As the hauling distance has an important bearing on the cost of the gravelling operation, the maximum acceptable hauling distance of a road for tractors and trailers will be limited to 10km. A road with a gravelling haul route exceeding 10 kilometres shall be gravelled by either using borrowed tippers from MOTC or by contract.

6.7 Work Execution

6.7.1 Identifying the Gravelling Need

The minor roads to be improved under Minor Roads Programme shall be all-weather. This means that, if in-situ material does not allow traffic to pass through during the wet weather, then the carriageway shall need to be gravelled.

Each road shall be considered separately as the haul distance and availability of gravel vary greatly.

If the in-situ material is itself gravel, then there will not be any need to gravel the road, however if the in-situ material is itself gravel on some sections of the road, then the other sections will be gravelled so that the whole road is passable.

When gravelling is necessary, the thickness of the loose gravel shall be 15 cm and 25 cm on other types of in-situ soils and black cotton soil respectively. This shall be spread on the whole width (5.4m) of the carriageway.

6.7.2 Location and Selection of Quarries

Quarries shall be located during evaluation exercise. Improvement works shall not start if the quarry location has not been established.

An Overseer, having a good knowledge of suitable gravel, shall be deployed along the road to be constructed, to try and locate suitable quarry or quarries. He shall work together with the local Chief and the people living along the road.

By showing them a sample of gravelling material the Overseer will be able to get assistance from the local people by being directed to various sources. These sources shall be marked and finally inspected by the Engineer.

e) Access to quarry

The access to the quarry shall be made passable. It pays to construct a proper access road before the hauling starts and to maintain it well throughout the gravelling operation.

6.7.3 Setting up the camp site

The gravelling camp shall be set up as close as possible to the quarry itself, and the unconnected trailers towed back to the camp from the quarry. The overseer and operators shall inspect the condition of all the tractors and trailers after each day's work.

The gravelling camp site shall consist of one hut for the overseer, huts for the drivers, one hut for washing, one latrine and two stores; one store for fuel, oil and lubricant and the other for tools and spares for tractors.

6.7.4 Preparation of quarry and road

This consists of:-

a) Reshaping of the road to be gravelled by bringing it back to its former state, with camber of 5-7% and correcting all depressions. This activity also includes improvement of all drainage system e.g. side drains, mitre drains, back slopes etc.

b) Bush clearing and stump removal on the access to the quarry. The access shall also be reshaped and surfaced with a thin layer of gravel if the in-situ material is very poor. The turning points for the tractors are also prepared the same time with the access. This should be big enough to enable tractors and trailers to turn without any problem.

c) Bush clearing and stump removal on the area covered by the quarry.

d) Stripping the top soil (overburden). This shall be done in stages. In the first stage, the stripping shall cover enough space to allow for the required number of loading bays. The other area shall be stripped of the top soil as the need arises.

This activity require two headmen, one on reshaping and the other one on quarry and access preparation with about 25 casual labourers depending on the vegetation covering the quarry and access and also the state of the road before reshaping.

6.7.5 Availability of equipment

Tractors and trailers shall be serviced before they start working. Tractors and trailers shall remain at the site camp until the work on preparation of the quarry and the access road is finished. The availability of tractor and trailers and the haulage distance are the determining factor of the number of casual labourers needed for loading, spreading and excavation. The number of trips and the number of casual labourers needed for each activity depending on the haul distance and the state of access to quarry is determined from the Gravelling Forms.

6.7.6 Gravelling Work

Gravelling work consists of:-

a) Excavation
b) Loading
c) Hauling
d) Off-loading and spreading

a) Excavation

Excavation and stock piling shall start immediately after quarry preparation. Excavation shall be done

in bays of about 3 - 4m width. Enough number of loading bays for the number or tractors available shall be ready with stockpilled gravel before the hauling starts. Excavation shall continue while the stockpilled gravel is being hauled. The initial excavation will be carried out by the Quarry Preparation Overseer.

b) Loading

Loading bays shall be excavated in order to reduce the manoeuvering time and simplify the loading by hand by reducing the height of the trailers. The loading bays have to be extended continuosuly as the quarry is being extended.

The maximum number of labourers who can load a trailer effectively is 4 while the number of labourers per tractor depends on the number of trips which is determined by hauling distance.

c) Hauling cycle

1. Tractor arrives, takes from the camp one of the empty trailer and delivers it to quarry.
2. Tractor deposits empty trailer on loading bay
3. Tractor collects the second trailer from the camp.
4. Tractor arrives and places the second empty trailer at the loading bay.
5. Tractor picks up loaded trailer
6. Tractor hauls loaded trailer to dump site
7. Trailer off-loaded and spread by hands
8. Tractor returns to quarry with empty trailer.

The number of trips per tractor will depend on haulage distance and the condition of the access (see table A and B.

d) Off-loading and Spreading

At dump place the width and length of the area for each load shall be properly pegged and strings used to mark the area.

When the tractor-trailer arrives with gravel, the labourers assigned to the tractor shall start off-loading and spreading according to the headman's instructions.

The off-loaded gravel shall be spread using spreaders and shovels and crush bigger materials with sledge hammers. The camber shall be checked with a camber board. The task rate for off-loading and spreading shall range from 12 to 16m^3 per manday - depending on the stiffness of the gravel.

MRP TASK RATES

GRAVELLING

Activity	Task Rate
Bush clearing	300 - 1000m^2/md
Excavation and stockpiling overburden	3 - 4 m^3/md
Hauling and dumping overburden	as per earth road improvement
Excavating and stockpiling gravel	2 - 3 m^3/md
Loading gravel	8 - 10 m^3/md
Offloading and spreading gravel	12 - 16 m^3/md

Table A "good" haul-route

Trips per day, daily accomplishment and number of workers for different haul-route standards and haul-distances(HD) and for various numbers of tractors

HD KM	Trips per tractor per day	4 tractors and 8 trailers					3 tractors and 6 trailers					2 tractors and 4 trailers				
		No. of workers				Daily accompl. ment(km)	No. of workers				Daily accompl. ment(km)	No. of workers				Daily accompl. ment(km)
		Exc	Load	Spr	Total		Exc	Load	Spr	Total		Exc	Load	Spr	Total	
0-1	18	-	-	-	-	-	-	-	-	-	-	34	14	8	56	0.200
1-2	14	-	-	-	-	-	39	18	9	66	0.235	26	12	6	44	0.156
2-3	11	40	16	8	64	0.246	30	12	6	43	0.184	20	8	4	32	0.123
3-4	9	36	16	8	60	0.200	27	12	6	45	0.150	18	8	4	30	0.100
4-5	7	28	12	6	46	0.156	21	9	4	34	0.117	14	6	3	23	0.078
5-6	6	24	12	5	41	0.134	18	9	4	31	0.100	12	6	3	21	0.067
6-7	5	20	8	5	32	0.112	15	6	3	24	0.084	10	4	2	16	0.056
7-8	4	16	8	4	28	0.089	12	6	3	21	0.067	8	4	2	14	0.044

RAR: TO BE UPDATED

Table B "Poor" haul-route

HD KM	Trips per tractor per day	4 tractors and 8 trailers					3 tractors and 6 trailers					2 tractors and 4 trailers				
		No. of workers				Daily accompl. ment(km)	No. of workers				Daily accompl. ment(km)	No. of workers				Daily accompl. ment(km)
		Exc	Load	Spr	Total		Exc	Load	Spr	Total		Exc	Load	Spr	Total	
0-1	18	-	-	-	-	-	-	-	-	-	-	34	14	8	56	0.200
1-2	12	-	-	-	-	-	36	15	9	60	0.200	24	10	6	40	0.134
2-3	9	36	16	8	60	0.200	27	12	6	45	0.150	18	8	4	30	0.100
3-4	7	28	12	6	46	0.156	21	9	4	34	0.117	14	6	3	23	0.078
4-5	6	24	12	5	41	0.134	18	9	4	31	0.100	12	6	3	21	0.067
5-6	5	20	8	4	32	0.112	15	6	3	24	0.084	10	4	2	16	0.056
6-7	4	16	8	4	28	0.089	12	6	3	21	0.067	8	4	2	14	0.044
7-8	3	12	6	3	21	0.067	9	4	2	15	0.050	6	3	2	11	0.033

RAR : To BE UPDATED.

CHAPTER 7.0: MAINTENANCE UNDER MRP

7.1 INTRODUCTION

A discussion paper is being prepared for distribution. This will form the basis of the INTERIM MAINTENANCE SYSTEM.

The Technology Unit will carry out investigations to refine the system in due course.

In the meantime only the essential features of the proposed maintenance system are detailed in this Manual.

Maintenance can be defined as those activities needed to be carried out on a road to simply preserve it from deterioration.

The long term success of MRP is dependent on the effectiveness of the maintenance system. The lengthman system which has been developed in RARP has been found to be effective and adequate to cater for the routine maintenance of the roads. The system has not only been found suitable because of ensuring that the roads are kept in good repair, but also because of providing employment and income in the rural areas. It is in recognition of these benefits that the Ministry of Transport and Communications has decided to extend labour-based methods of maintenance to minor roads.

The maintenance of minor roads will consist of two main operations namely routine and periodic maintenance.

7.2 ROUTINE MAINTENANCE

Routine maintenance is a continous operation which includes the following:-

a) Patching of potholes: This activity involves the repair of the carriageway damaged by filling the

potholes as follows:-

i) Earthroads: The potholes will be filled with the in-situ material obtained from the road side.

ii) Gravel roads: The potholes will be filled with gravel obtained from the stacks placed by the road side when the road was being gravelled.

b) Cross-shaping of the road. This operation involves the maintenance of the carriageway and shall be performed by raking the road.

c) Ditch Maintenance: Maintenance of the carriageway will only be effective if adequate maintenance is given to the ditches. The ditches will be kept clear by removing silt, reinstatement of scour-checks to prevent soil erosion ect.

d) Maintenance of structures and road signs: The work includes cleaning of culverts and maintenance of the associated masonry, construction of gabions and replacement of painting of road signs.

e) Maintenance of right-of-way: This operation will involve clearing well back from the carriageway trees and scrub so that the wind and the sun can have full play in drying the road surface.

Routine maintenance will continue to be based on the 'lengthman' system as used for the maintenance of the rural access roads. Under the system developed for the RARP, a road is divided into sections and a reliable ex-construction worker contracted to carry out the maintenance work for a specific section. The average length of one section in RARP is about 1.5 km. It is expected that the length of one section to be maintained

by a contractor in MRP will be between 1.2 and 3.0 kms depending on maintenance requirements.

The contractor will be a local farmer who lives with his/her family on his farm adjacent to the section of road for which he is responsible. They will be provided with the necessary tools and paid on a monthly basis the equivalent to 12 days wages for a construction worker (currently Kshs. 276 per month). Unlike construction workers the maintenance contractors cannot be supervised on a continuous basis and at best can be visited by a supervisor once a week. Therefore the system is based on payment by results, no check is made of the number of days or hours worked, the only requirement is that the road section is maintained to the approved standard.

Each road is inspected once a month and the contractors paid provided the required standard has been achieved In cases where the standard is not met the payment is withheld and the contractor warned that the contract will be terminated if during the next scheduled inspection the section is found to be sub-standard. If during the subsequent inspection the section is found to be satisfactory, payment is made for two months, otherwise the contract is terminated and is replacement sought.

Essential supervison is provided by one Inspector and Overseers. Each Overseer is in charge of up to 100 contractors. The Inspector is allocated a pick-up to enable him to make the monthly inspections and payments to the contractors. Motorcycles are provided for the Overseers who are expected to visit each road at least twice a month when they are required to give guidance to the contractors to help them improve their performance In addition the Overseers are required to accompany the Inspector during his monthly inspection in order to have the opportunity to discuss and resolve problems on site and to act as witness to the payments. On the whole, the

system has functioned reasonably well, but there has been a wide variation in the standards achieved.

There is some concern that the present "all or nothing" payment system should be revised to reflect maintenance task priorities and to offer greater incentive to the contractors to work harder. For example, the payment might be based on 6 days for work on the carriageway, 3 days for drainage work and 3 days for vegetation control. The decision to pay the contractor for each work item would still depend on the standard achieved but it would be less likely that the total payment would be withheld and it is considered that he would be more likely to try harder during the following month. Before making any revision to the present system, it is proposed to study the traffic, topographical and climatic conditions. The results are expected to provide a better basis of determining the length of the road section to be maintained by an individual contractor which should ensure that a more uniform standard of maintenance is achieved. Gravel stockpiles will be replenished by gravelling/regravelling sub units working in the area.

Regravelling (Periodic Maintenance)

Regravelling will be restricted to those sections where it is obsolutely essential in order to meet the minimum level of service expected from the road. At present, no data is available to indicate what proportion of the roads constructed under the RARP and proposed MRP will require regravelling/heavy patching on an annual basis. However, it is generally accepted that under ideal circumstances, such roads should be regravelled on an eight year cycle with sections on steep grades or in high rainfall areas receiving more frequent attention.

It is proposed that each district be equiped according to need by reassigning serviceable equipment from the RARP as the latter is phased out. In exceptional cases, where it is proposed to regravel a long continous section of road or where the haul distance exceeds 10 km consideration will be given to letting a contract.

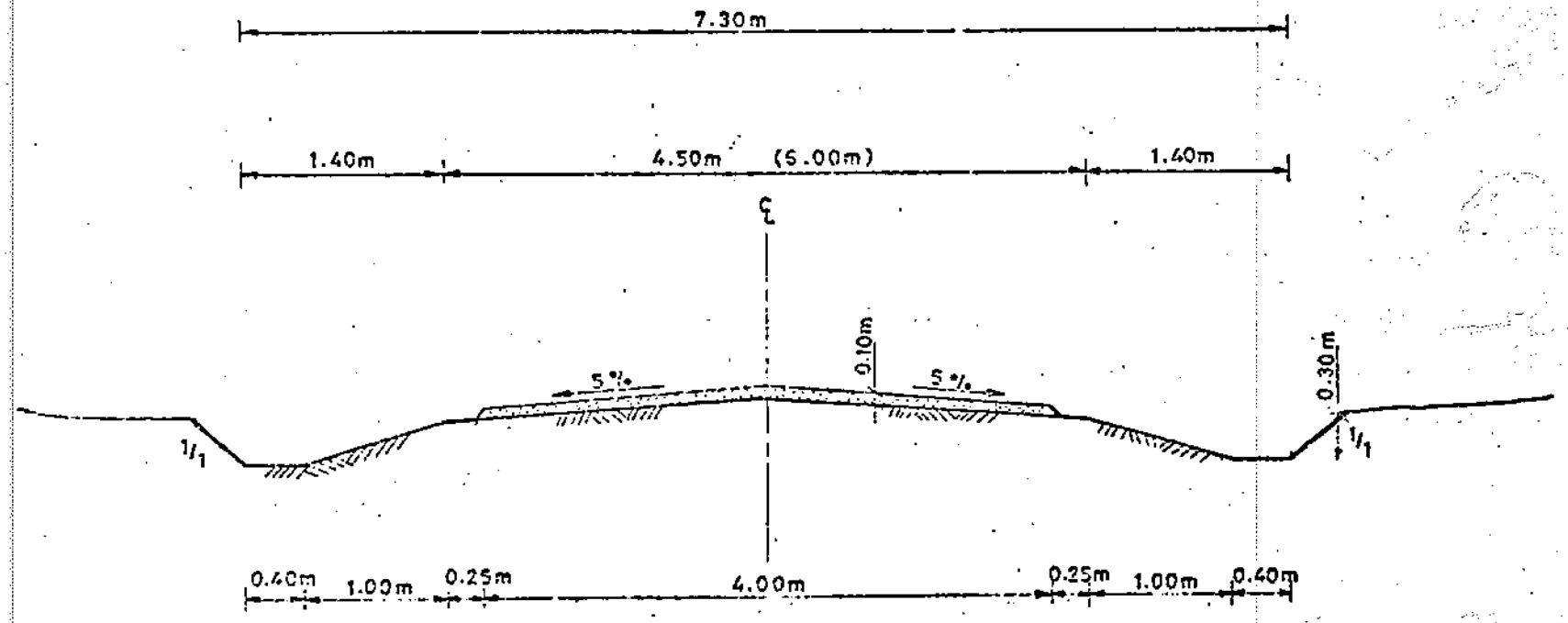
It is anticipated that the introduction of headmen and improved systems of direction and control of contractors will significantly improve maintenance standards under the INTERIM MAINTENANCE SYSTEM.

A P P E N D I X I

RURAL ACCESS ROADS STANDARDS

RAR

STANDARD CROSS SECTION - I



SCALE:- 1: 50

NOTES:

1. Width of earth road formation 4.50m for less than 30 vehicles per day.
   " " " " " 6.00m " more " " " " "