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Government of Lesotho

Ministry of Works

Roads Branch

LABOUR CONSTRUCTION UNIT

Technical Manual

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Peter Guthrie
March 1983

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CHAPTER 1

INTRODUCTION

INTRODUCTION

What is this manual about?

This manual is about

CIVIL ENGINEERING CONSTRUCTION
USING LABOUR BASED METHODS

It is intended to be a field manual for supervisors on site.

It is written so that no previous technical experience is necessary, but it contains a lot of information which would be useful for anyone who supervises labour based works.

Chapter 2 describes the BASIC SKILLS which are required to read this, or any, technical book.

Chapters 3, 4, 5, 6, and 7 are about Road Construction and Maintenance. This is the main part of works carried out by the Labour Construction Unit, so these chapters go into detail.

Chapter 8 gives information on Conservation Works.

Chapter 9 gives information on Airstrip Works.

Chapters 10 and 11 on Soil Mechanics and Concrete Technology are important for understanding what happens to materials used in construction.

Chapter 12 gives a brief description of Setting Out. Because this subject needs so much practical demonstration, it cannot be covered fully in this manual.

INTRODUCTION

Continued

Chapter 13 is very important. It describes Taskwork and Production Records. Taskwork is the basis of most work done in the L.C.U. It is the business of giving a man a certain amount of work for one day's pay. How to choose that "amount of work" is a vital part of a supervisor's job. Throughout chapters 3 to 9, typical tasks are given. In Chapter 13 it is all explained in detail.

Chapter 14 describes the process of setting up a site. Not everyone who reads this manual will have to do this, but it is important that everyone understands what work is involved.

The manual is to be used, read, and discussed. It may form the background to the training of technical staff. It is not a book of rules, but rather a book of ideas and guidelines to help staff understand better what they have to do.



When a detail slips your mind
In this book the facts you'll find
Keep this manual close to you
It will help to get you through

CHAPTER 2

BASIC SKILLS

BASIC SKILLS

What are the Basic Skills?

The basic skills are the things you have to be able to do before you can use this book properly

BASIC SKILLS
ARE THE
TOOLS OF
UNDERSTANDING

Among the basic skills are:

- Measurement of length
- Basic Arithmetic
- Calculation of Area
- Calculation of Volume
- Understanding of : PLAN
ELEVATION
CROSS SECTION

Make CERTAIN you understand this chapter BEFORE you go on with the rest of the book.

Basic Skills are not all very easy.

If you are not certain you understand all the parts of this chapter, go through it carefully and ask your engineer to explain it to you.

Remember

It is UNLIKELY that all this chapter will be familiar to you

So don't be afraid to ask for help

MEASUREMENT OF LENGTH

To do almost any job in construction you need to know how to measure length

When building a road for example you need to know:

How long is the road?
How wide is the road?
How deep is the ditch?
How long is the culvert?
How wide is the river?
How long is the ...

So many questions...
and for each of them
you need to know how to
measure length.

(Length is a general term for length, width, depth)

Length is measured in many ways. In Lesotho we use METRES and MILLIMETRES

Metres

To give you a rough idea, one metre is about the length of a man's stride

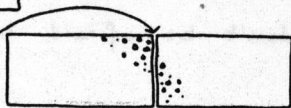


This distance is about 1 metre. Often written 1m.

Millimetres

A millimetre, on the other hand is very small

The gap between these two blocks



is about 1 millimetre. Often written 1mm or 0.001m

MEASUREMENT OF LENGTH

continued

There are 1000, yes one thousand millimetres in one metre.

So in decimals:

$$1 \text{ m} = 1000 \text{ mm}$$

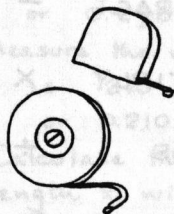
$$1 \text{ mm} = 0.001 \text{ m}$$

Measurement of length is done most often with a TAPE

A tape is made of steel or plastic and has length marked on it in metres and millimetres.

Tapes come in different lengths :

- 3 metres
- 10 metres
- 30 metres



Example

Measure the length of a pick handle



Read the length marked on the tape at the other end of the pick handle:

Hold the end of the tape firmly at one end of the pick handle

this is the length of the pick handle

Is that clear to you?

If not, go and find someone who is good at measuring and ask them to explain

AREA

continued

Area is always two measurements of length multiplied together.

Area is usually length \times width

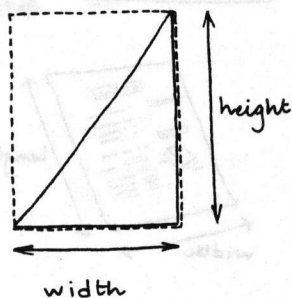
But there are more complicated shapes

Here are a few useful examples

Area of a triangle

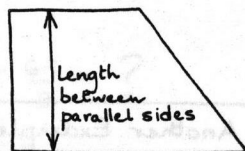
$$\text{Area} = \frac{1}{2} \times \text{height} \times \text{width}$$

(This is because the triangle is half the area shown -----)



Area of a trapezium

$$\text{Area} = \frac{1}{2} (\text{sum of parallel sides}) \times \text{length between these sides}$$



in other words:

$$\text{Area} = \left(\frac{\text{Average length of}}{\text{parallel sides}} \right) \times \text{length between these sides}$$

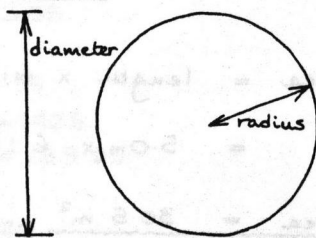
length of other parallel side

Area of a circle

$$\text{Area} = \pi \times \text{radius} \times \text{radius}$$

$$= 3.14 \times \text{radius} \times \text{radius}$$

Remember diameter = $2 \times$ radius



AREA EXAMPLES

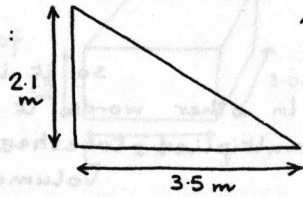
Example

What is the area of :

It's a triangle

$$\text{Area} = \frac{1}{2} \times \text{width} \times \text{height}$$

$$= \frac{1}{2} \times 3.5 \times 2.1 = \underline{3.675 \text{ m}^2}$$



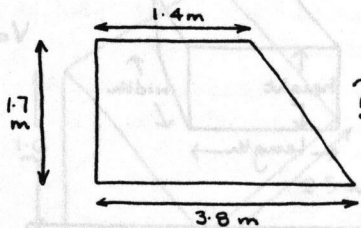
Another Example

What is the area of :

It's a trapezium.

$$\text{Area} = \frac{1}{2} (1.4 + 3.8) \times 1.7$$

$$= 2.6 \times 1.7 = \underline{4.42 \text{ m}^2}$$



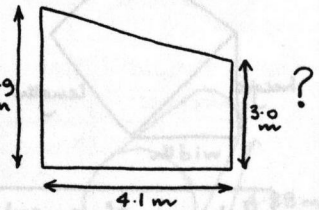
And Another Example

What is the area of :

It's another trapezium

$$\text{Area} = \frac{1}{2} (5.9 + 3.0) \times 4.1$$

$$= \underline{18.245 \text{ m}^2}$$



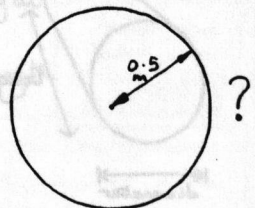
And the Last Example

What is the area of

It's a circle

$$\text{Area} = 3.14 \times \text{radius} \times \text{radius}$$

$$= 3.14 \times 0.5 \times 0.5 = \underline{0.785 \text{ m}^2}$$



VOLUME

What is volume?

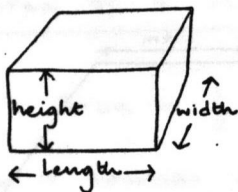
Volume is
 $\text{Length} \times \text{width} \times \text{height}$

so it is also $\text{area} \times \text{height}$
 In other words it is three measurements of length multiplied together.

Volume is measured in cubic metres, m^3

Volume of a box

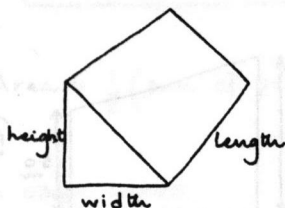
This applies to anything which has the shape of a box



Volume = $\text{length} \times \text{width} \times \text{height}$

Volume of a wedge

In some cases it is easier to calculate volume as $\text{area} \times \text{length}$

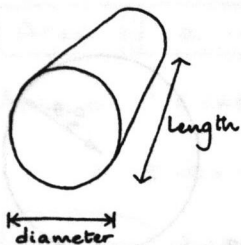


The area of end of the wedge is $\frac{1}{2} \times \text{height} \times \text{width}$

The volume of the wedge is $\text{area} \times \text{length}$

Volume of a cylinder

Volume = $\text{area of the circular end} \times \text{length}$



Volume = $\pi \times \frac{\text{diameter}}{2} \times \frac{\text{diameter}}{2} \times \text{Length}$

VOLUME EXAMPLES

Example

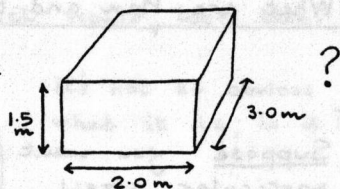
What is the volume of

It's the shape of a box.

Volume = length \times width \times height

$$= 3.0 \times 2.0 \times 1.5$$

$$\underline{\text{Volume} = 9.0 \text{ m}^3}$$



Another Example

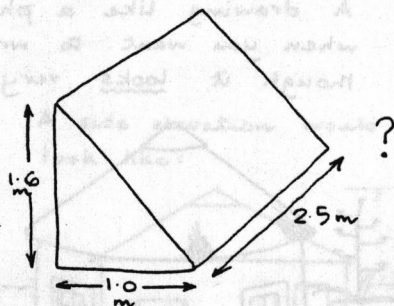
What is the volume of

It's the shape of a wedge

Volume = area of end of wedge \times length

$$= \frac{1}{2} \times 1.0 \times 1.6 \times 2.5$$

$$\underline{\text{Volume} = 2.0 \text{ m}^3}$$



And the last example

What is the volume of

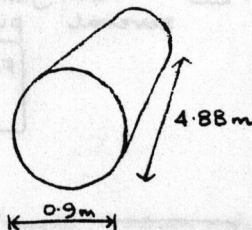
It's a cylinder

Volume = area of the circular end \times length

$$= \pi \times \frac{\text{diameter}}{2} \times \frac{\text{diameter}}{2} \times \text{length}$$

$$= 3.14 \times \frac{0.9}{2} \times \frac{0.9}{2} \times 4.88$$

$$\underline{\text{Volume} = 3.10 \text{ m}^3}$$



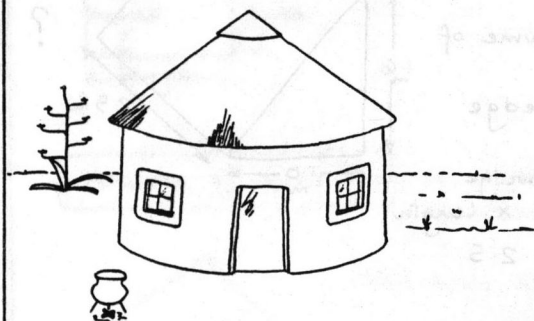
PLAN & ELEVATION

What are Plan and Elevation? Plan and Elevation are special ways of drawing an object to make measurement and construction easier.

Suppose you want to build a rondavel of a particular size.

To give you all the dimensions (lengths, heights etc.), you need a DRAWING

A drawing like a photograph can be very confusing when you want to write on it the dimensions, even though it looks very like the rondavel you want.



For someone trying to build the rondavel, this picture is no good. It doesn't show the foundation size, the wall thickness, the door size, and so on and so on.

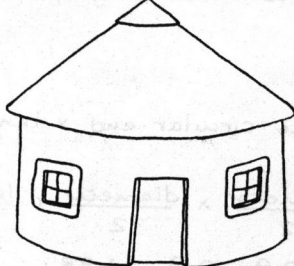
So the system used in construction is to draw several pictures from special positions.

From directly
ABOVE

called a PLAN

From the side

called a
SIDE
ELEVATION



From in
front

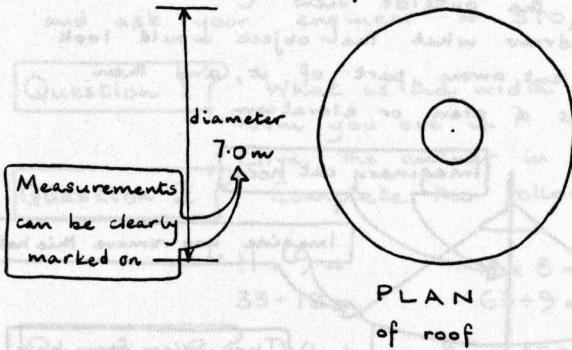


called a
FRONT ELEVATION

PLAN & ELEVATION

So a PLAN of the rondavel would look like:

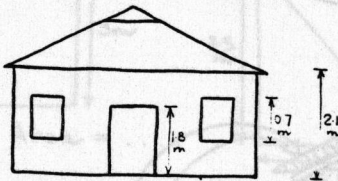
Continued



It's not so obvious what it is, is it?

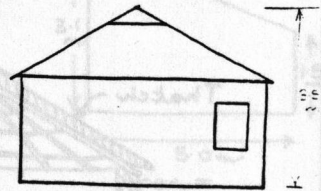
However it makes the construction easier which is why it is used.

A front elevation would look like:



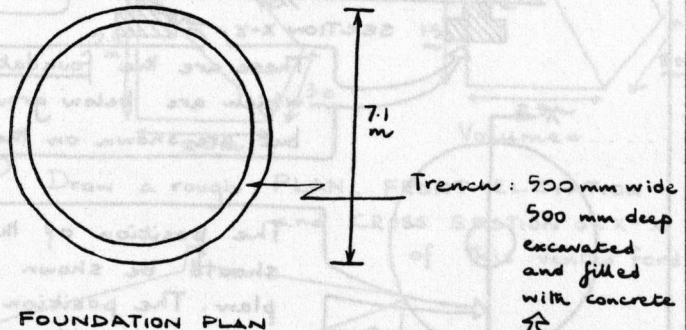
FRONT ELEVATION

A side elevation would look like:



SIDE ELEVATION

A plan of the foundation would look like this:



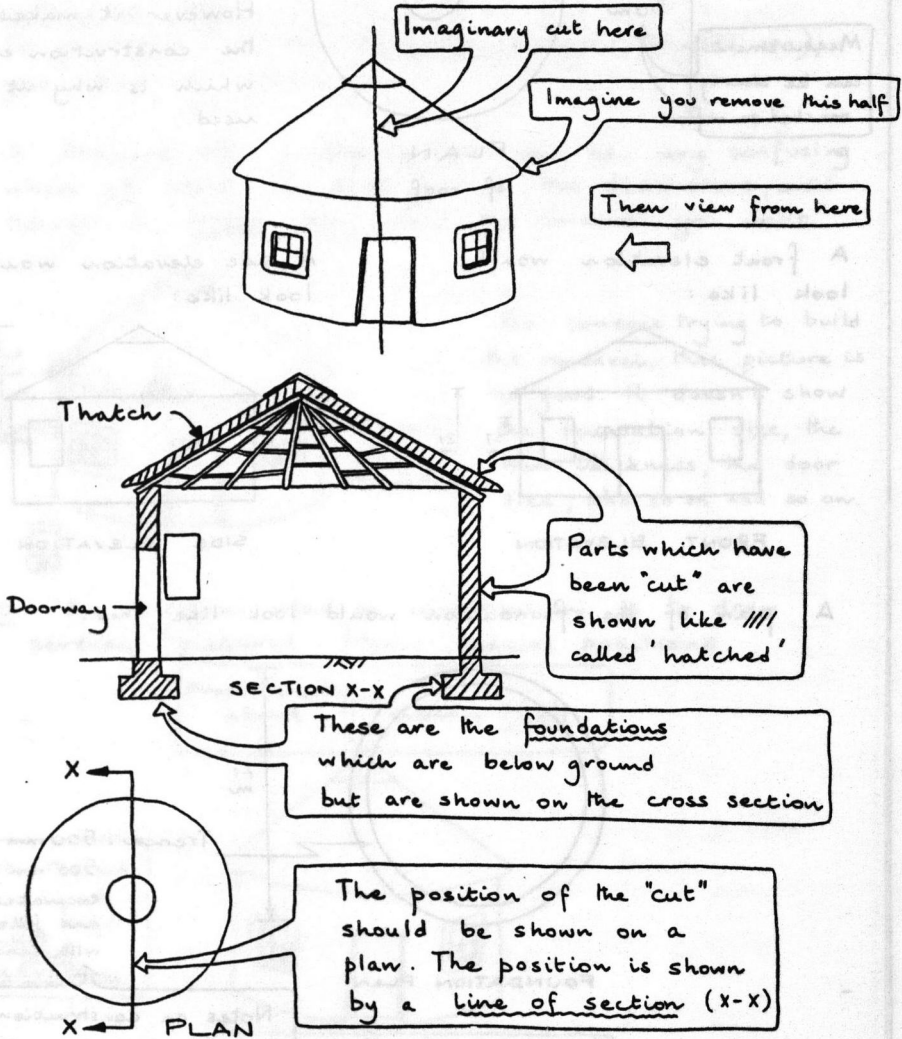
FOUNDATION PLAN

Notes on construction may be included on the plans and elevation

CROSS SECTION

Sometimes you need to know what the dimensions and details are behind the outside view

To draw this, you draw what the object would look like if you could cut away part of it, and then draw that view as a plan or elevation.



BASIC SKILLS_A QUIZ

Write down your answers on another sheet of paper and ask your engineer or STO/PTO to check them.

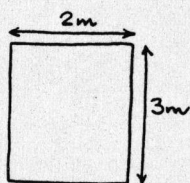
Question 1? What is the width of the door of the room you are in?

Give the answer in metres

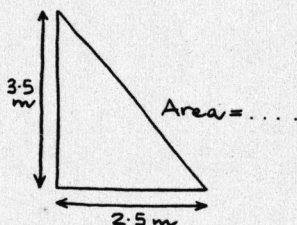
Question 2? Complete the following sums:

$$\begin{array}{lll} 11 + 9 = \dots & 11 \times 8 = \dots & 2.7 \times 0.8 = \dots \\ 33 - 12 = \dots & 63 \div 9 = \dots & 24 + \frac{1}{2} = \dots \end{array}$$

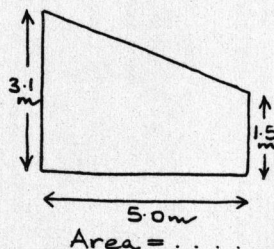
Question 3? What is the AREA of the following figures:



Area =

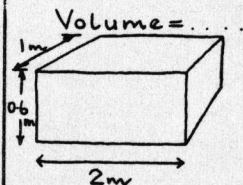


Area =

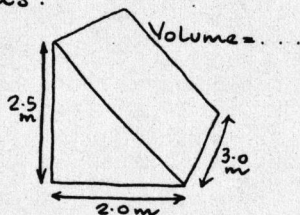


Area =

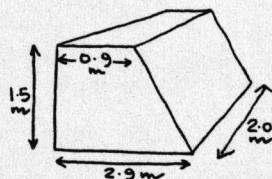
Question 4? What is the VOLUME of the following objects:



Volume =

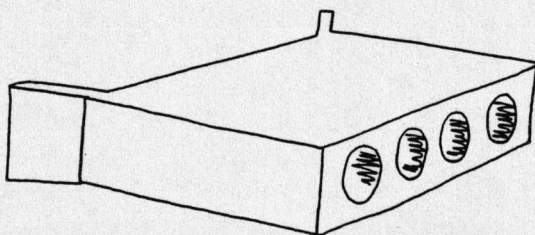


Volume =



Volume =

Question 5? Draw a rough PLAN, FRONT ELEVATION and CROSS SECTION on X-X of this vented ford.



EARTHWORKS

CHAPTER 3

EARTHWORKS

Earthworks is the process of clearing and

ROADS

APPROACH

CONSTRUCTION

EXTENSION

GENERAL EXCAVATION

This chapter deals with the following topics:

Major Earthworks in detail are:

- Site clearance
- Excavation of ditches
- Excavation of drainage ditches
- Excavation of waterways
- Excavation of roads
- Grading, filling, widening, etc.

EARTHWORKS

What is earthworks?

Earthworks is the business of clearing site, digging, moving and spreading soil, weathered rock and rock.

Earthworks is involved in:

ROADS
AIRFIELDS
CONSERVATION
FISHPONDS
GENERAL EXCAVATION

This chapter deals with earthworks on Roads

Roads Earthworks is divided into:

- Site clearance
- Excavation of topsoil
- Excavation of ordinary soil
- Excavation of weathered rock
- Excavation of rock
- Loading, hauling, unloading, spreading, compacting

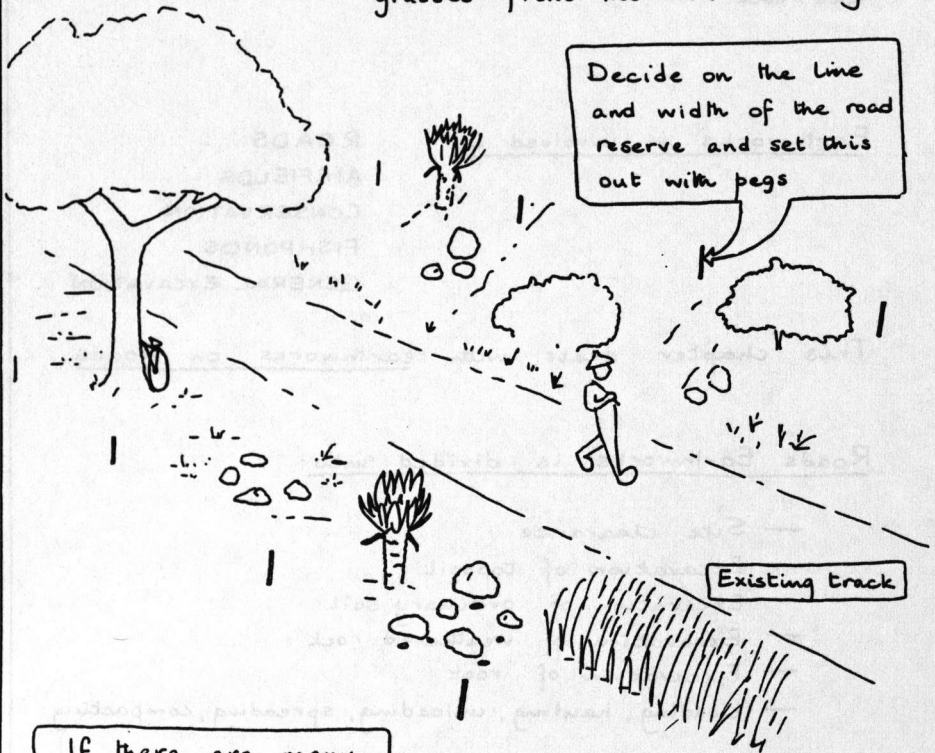
Example

You have dug holes 10m x 10m x 1m deep. The topsoil is 1m deep. The ordinary soil is 1m deep. The weathered rock is 1m deep. The rock is 1m deep. The total depth is 4m. The total area is 100m². The total volume is 400m³. The total cost is 400m³ x 100m³ = 40,000m⁶.

SITE CLEARANCE

What is Site Clearance?

Site clearance is the removal of all trees, bushes and tall grasses from the new roadway.



If there are many bushes and thick long grass, or any trees, site clearance is necessary using a separate gang before excavation begins

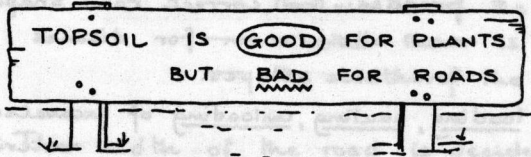
If there are no trees and not much thick long grass and bushes go straight on with topsoil stripping.

Because site clearance is usually not necessary in Lesotho, the task will be set by the engineer when necessary.

EXCAVATION OF TOPSOIL

What is topsoil?

Topsoil is the soil near the surface which plants grow in.



Topsoil must be removed from the roadway

Soil which is not topsoil is called SUBSOIL

With a little experience you will be able to tell the difference between topsoil and subsoil.

Excavation of topsoil

Method

Step 1

Dig several holes about 10m apart to find out how deep the topsoil is in the area you are working in.

Step 2

Using the depth of topsoil you have measured, calculate the area each man must excavate to achieve his task.

Pegs marking area to be excavated

Activity

Excavate TOPSOIL	task 5.0 m ³ /manday
------------------	---------------------------------

Example

You have dug holes and found the topsoil is about 0.2m deep.

The task is 5.0 m³/manday

So the area is the $\frac{\text{task volume}}{\text{depth}}$

$$\text{Area} = 5.0 \div 0.2$$

$$= 25 \text{ m}^2/\text{manday}$$

So set out areas of 25 m²

(maybe 5m x 5m or 10m x 2.5m)

EXCAVATION TO FORMATION

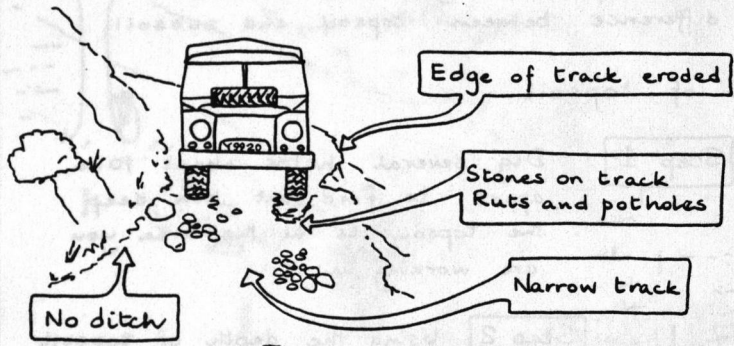
What is Formation?

Formation is the excavation and shaping to produce the correct road shape and allow room for ditches and side slopes.

Shaping may include loading, hauling, unloading of excavated material

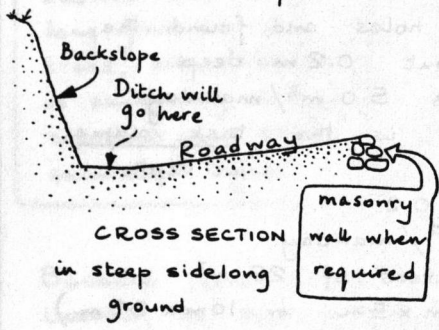
Shaping will include spreading and compacting of excavated material.

Existing tracks often look like this:

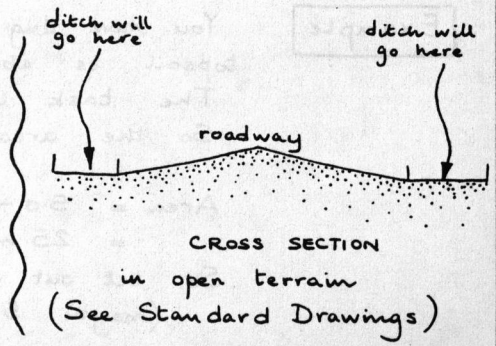


These tracks are hopeless for vehicles when it rains because the water turns the road to mud.

So FORMATION is the first step to making a good road
Two common shapes are:



CROSS SECTION in steep sidelong ground



CROSS SECTION in open terrain
(See Standard Drawings)

EXCAVATION TO FORMATION

continued

The WIDTH of formation depends on:

- the width of the road
- the width of the ditch
- whether there is to be one or two ditches
- the width of the backslope.

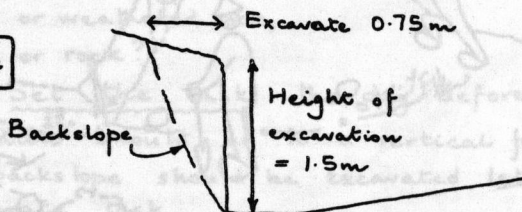
The width of the road is decided before the job begins but can be reduced when the terrain is very severe. The width of the ditch is decided according to the type of road and the terrain.

Whether one or two ditches are required is determined by the terrain.

The width for backslope. Allow 1 m extra horizontal width of formation for each 2 m of height of bank.

Backslope

Example



When the width of formation has been decided, the route is set out using pegs.

Formation width is horizontal distance between pegs

Pegs set out every 10m along the route

EXCAVATION TO FORMATION

Now you know: What Formation is, continued
How to decide the width of Formation

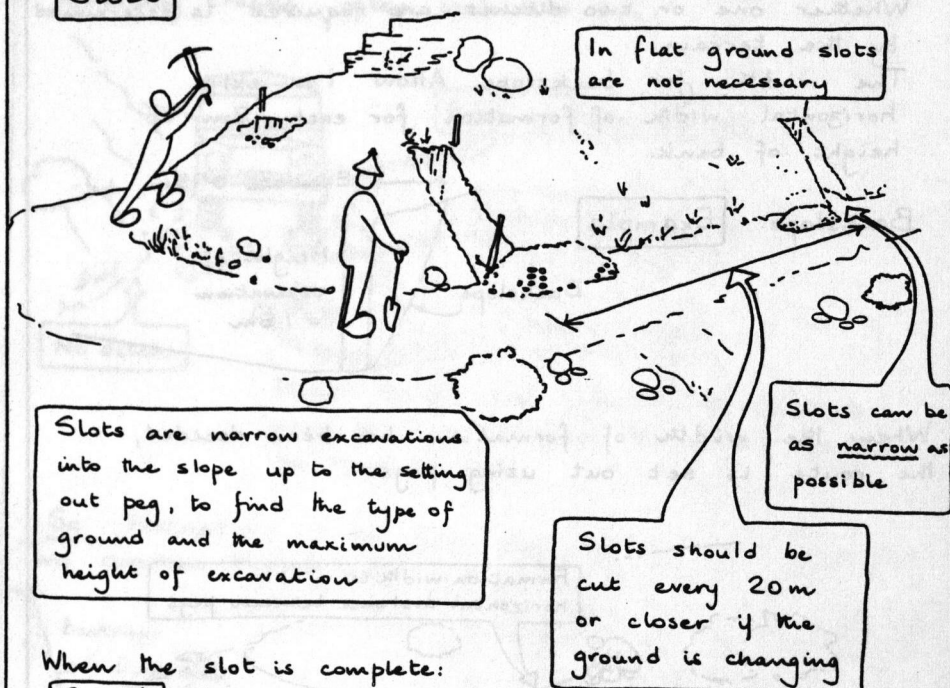
Now you need to know how to organise excavation

Excavation is done as TASKWORK.

To set the task, you need to know how to calculate the volume.

To calculate the volume, you must know: the length
the width
the height.

Slots



When the slot is complete:

Step 1 Look at the material:

is it ordinary soil, weathered rock or rock?

Step 2 Choose a task per manday in m^3

Step 3 Measure height and width of slot side and calculate the AREA of the slot side.

Step 4 Divide the volume task by the area to give a task of length per manday

EXCAVATION TO FORMATION

There are many different types of ground but they can all fit into one of only three groups:

continued
ORDINARY SOIL
WEATHERED ROCK
ROCK

Excavation of rock requires special methods which are explained later.

The methods for excavation of ordinary soil and weathered rock are the same:

Tools

1 pickaxe per man

1 shovel per man

Method

Step 1

Decide on the type of ground: is it ordinary soil, or weathered rock, or rock?

Step 2

Set the task the day before.

The excavation should be to a vertical face and the backslope should be excavated later as a separate task.

The task is set as follows:

Excavate ordinary soil	task 5.0 m ³ /manday
Excavate weathered rock	task 2.5 m ³ /manday

If a slot has been cut, calculate the area of the side of the slot.

If not calculate the cross sectional area of the ground to be excavated.

Using the task in m³/manday shown above, divide the task m³/manday by the area m²

This gives you a LENGTH PER MANDAY

EXCAVATION TO FORMATION

continued

You now know the length each man must excavate to achieve his task.

Step 3

Mark out the task on the ground and EXPLAIN to each labourer the task he must do.

Remember

The task of excavation includes throwing the material across the road.

If the material needs to be moved along the road the task becomes excavate and load into wheelbarrows.

The hauling of the material is a separate activity.

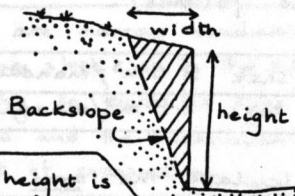
Step 4

The excavated material, now called COMMON FILL must now be spread and compacted to the correct crossfall or camber (see ROAD SURFACE DRAINAGE)

Spread and compact common fill	task $20\text{m}^3/\text{manday}$
--------------------------------	-----------------------------------

Step 5

As a separate task the next day excavate the backslope.



Measure the height. Divide this by 2 - this is the width to be excavated as shown.

If the height is more than 2m make a horizontal step 1m wide at 2m height.

Task setting is calculated the same way as above.

Excavation to Formation is now complete

ROCK IN FORMATION

What do you do when there is rock in the formation?

Excavation of rock is always difficult and expensive. So, there are three ways to deal with rock when it appears in the formation width:

1. Build the road on top of the rock
2. Excavate the rock by hand tools
3. Excavate the rock by drilling and blasting.

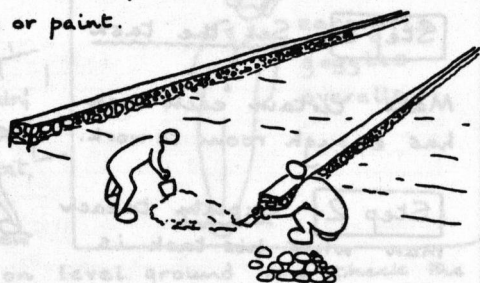
Build the road on top of the rock

This can only be done when the rock is fairly flat.

Method

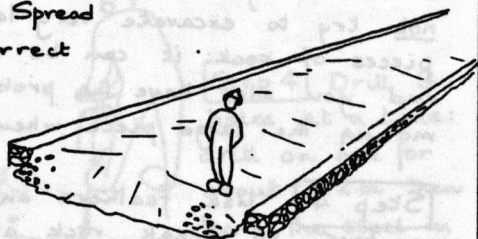
Step 1 Set out the line of the road with pegs or paint.

The correct width is shown on Standard Drawing



Step 2 Build cement masonry walls along each side of the road

Step 3 Bring in common fill between the walls. Spread and compact to the correct shape



Step 4 If the road is to be gravelled, spread and compact the gravel as usual (explained in GRAVELLING Section)

EXCAVATION OF ROCK

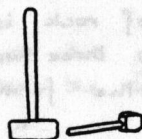
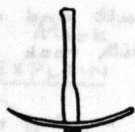
By Hand Tools

Tools

Pickaxe

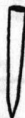
Chisels

Hammers



Feathers and wedges

Rock drills



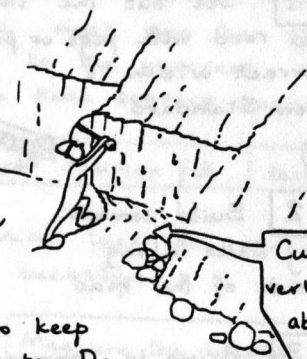
Method

Step 1 Set the task

Make certain each man has enough room to work.

Step 2 Explain to each man what his task is.

Step 3 Always try to keep a vertical face to excavate. Do not try to excavate very large pieces of rock: it can be slower and you also have the problem of moving the large piece when it has been excavated.



Step 4 Use feathers and wedges in groups of three or four to break rock along a line.

Step 5 The excavated rock should be thrown evenly across the road except where the pieces of rock would damage vehicles

Excavate rock

task 1.0 m³/manday

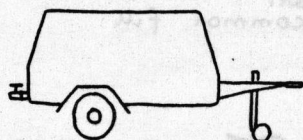
EXCAVATION OF ROCK

continued

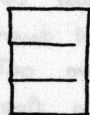
By drilling and then blasting

This method is used where there are large volumes of rock to be excavated.

Tools



Compressor

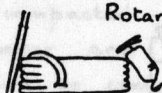


Fuel



Oil

Drill steels
1m and 2m long



Rotary drills

Hoses and clips

You will also need a vehicle to tow the compressor

Method

Step 1

Make certain the compressor is complete with all tools, oil, fuel and so on.

Step 2

At each new place, stand the compressor on level ground and check the oil (engine and compressor) and fuel.

Step 3

Drill holes on a grid which is 0.6 m x 0.6 m.



Step 4

Drill 3 holes at a time: drill on one for about 0.2 m then leave the steel in and move to drill 0.2 m on the next steel and so on

Step 5

Stuff grass or shrub into the top of each hole to keep the hole clean

Operators must wear



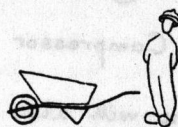
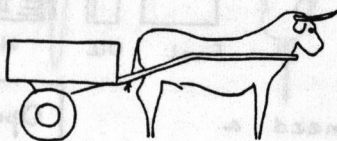
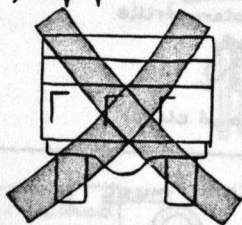
earmuffs
goggles
overalls

LOADING HAULING UNLOADING SPREADING

What is that all about? Sometimes it is necessary to move common fill along the road, to make the road less "up and down"

Use wheelbarrows or animal carts but...

Never use a tipper to haul common fill



Loading and excavating are parts of the same activity:

Excavate and load ordinary soil	task	5.0 m ³ /manday
Excavate and load weathered rock	task	2.5 m ³ /manday

Hauling and unloading are parts of the same activity:

Haul and unload common fill by wheelbarrow	task	5.0 m ³ /manday
--	------	----------------------------

By ox cart or donkey cart the task will be set by the engineer or PTO

Spreading is done using shovels and rakes

Spread common fill	task	20 m ³ /manday
--------------------	------	---------------------------

COMPACTION

What is compaction?

Compaction is pressing soil together to make it denser and stronger

Water is needed to get good compaction

The right amount of water is IMPORTANT:

Too little water and the soil doesn't want to be compacted.

Too much water and the soil becomes soft and can't be compacted properly

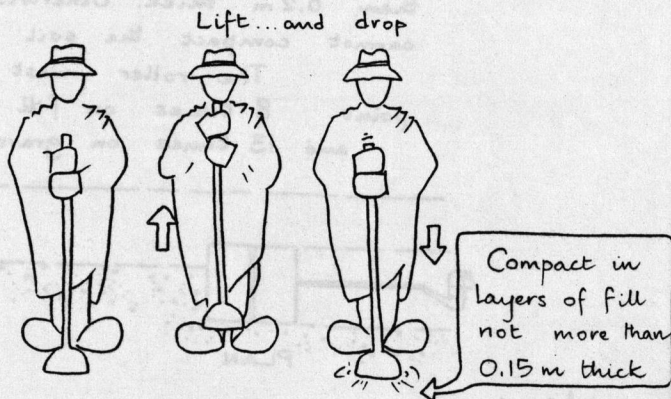
There are two methods of compaction: BY HAND BY MACHINE

By Hand

Tools

Hand Rammers

Method



Rammer is Lifted and dropped...again and again.

Hand compact common fill

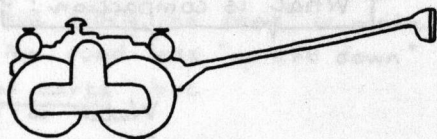
task 15 m³/manday

COMPACTION

continued

By Machine

Equipment



Generally, a VIBRATING ROLLER is used.

This is a roller that shakes itself around and so does more compaction than if it rolled along without shaking.

Method

Step 1

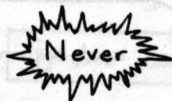
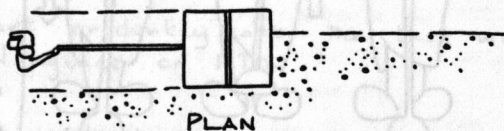
Make sure the roller has the fuel and oil checked every day.

Step 2

When the fill has been spread in layers to the correct shape and when the water has been added, drive the roller along the line of the road.

Each layer must not be more than 0.2m thick. Otherwise, the roller cannot compact the soil properly.

The roller must pass over every point 8 times on fill and 13 times on gravel.



Never

allow anyone other than the operator to use the roller.

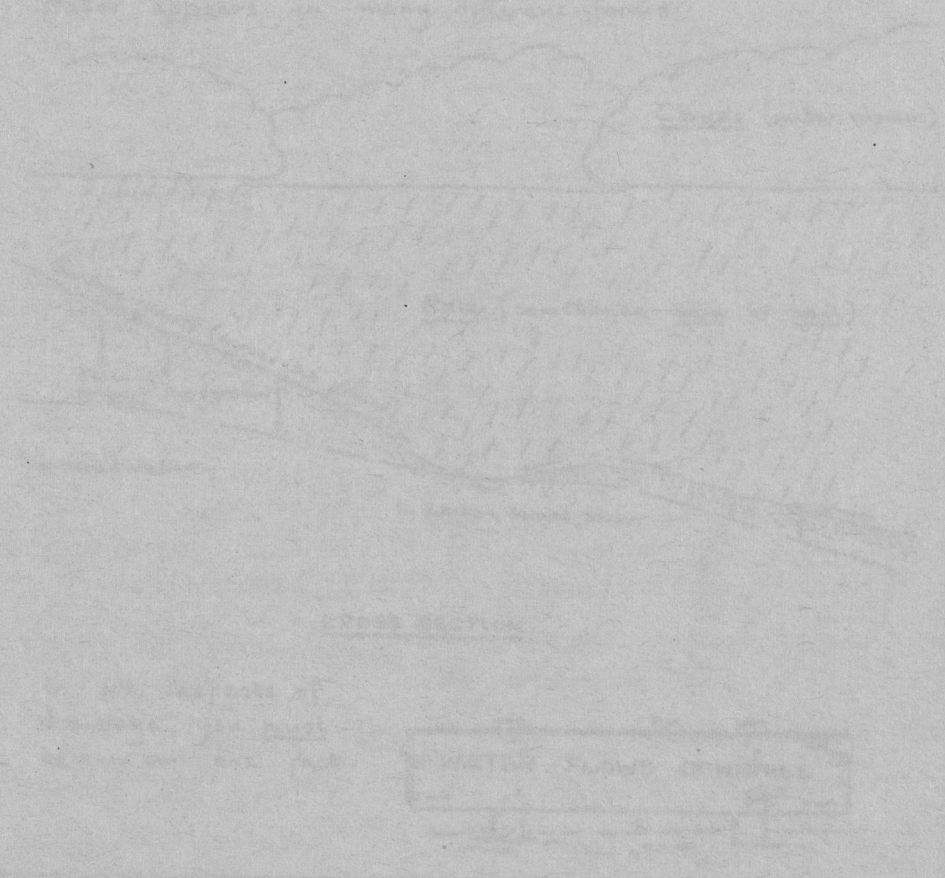
Remember

if the roller sounds funny or is not working well report this immediately to the officer in charge.

DRAINAGE

CHAPTER 4

DRAINAGE



DRAINAGE

What is Drainage? Drainage is the Control of Water

Why bother to control water?

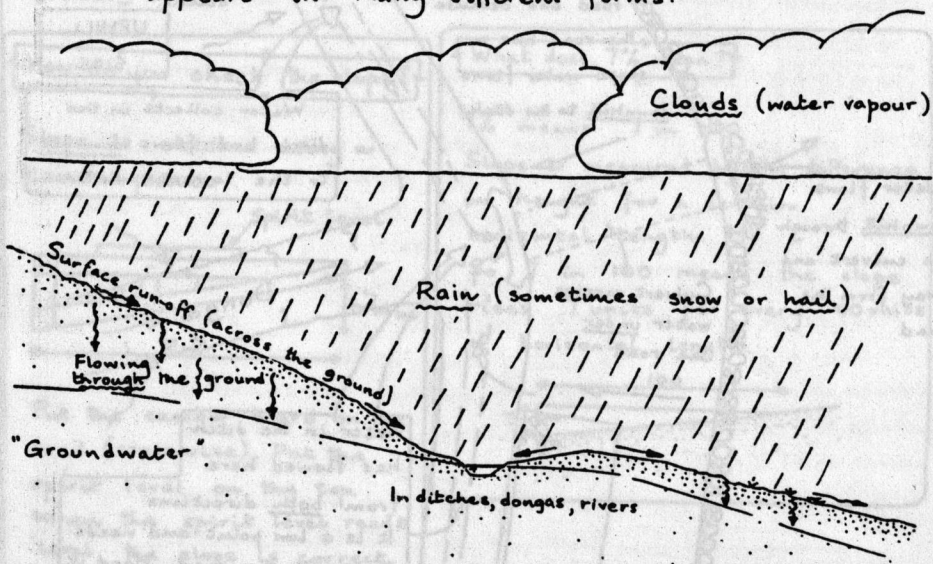
Because water can **DAMAGE** a road:

- by washing away the road
- by soaking the road and making it weaker.

But if the water is controlled, the road will survive.

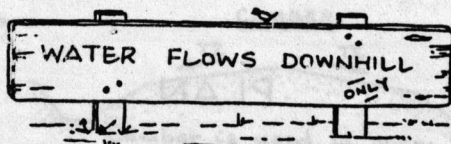
A well drained road is a good road.

Water appears in many different forms:



CROSS SECTION

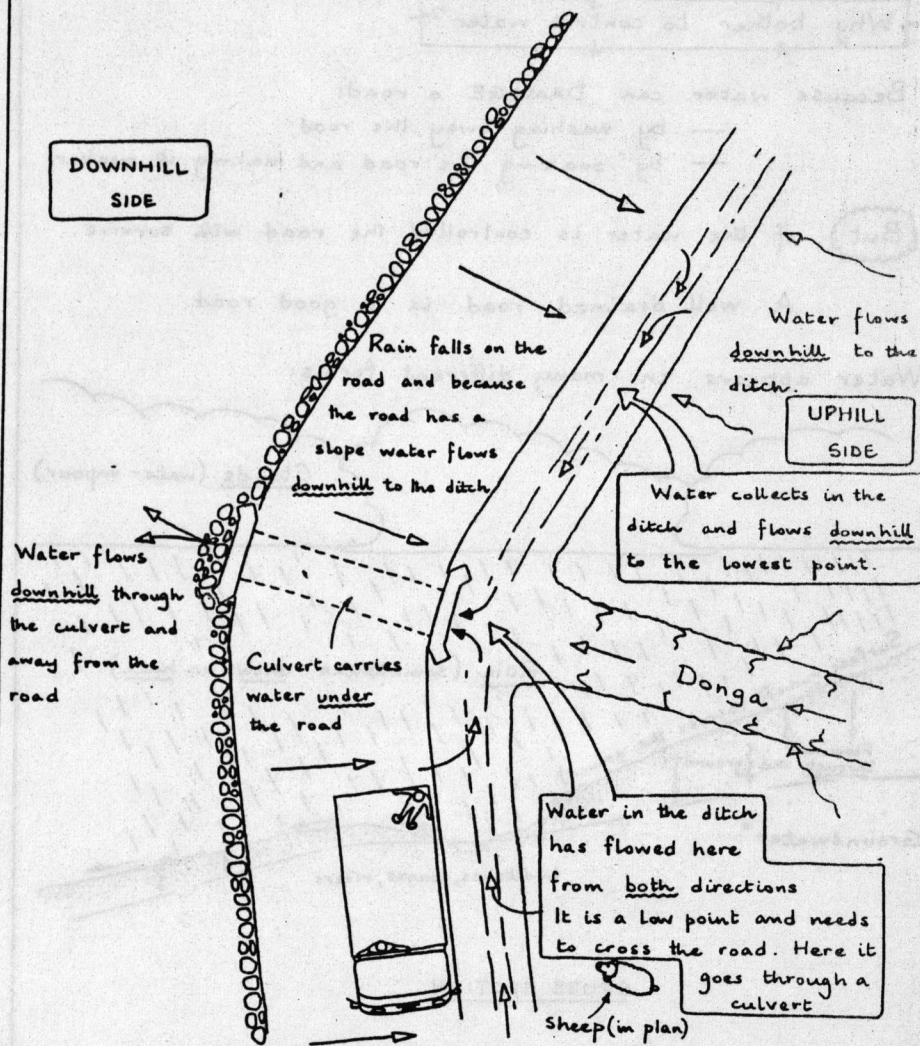
In all aspects of drainage, you must remember one fact:



DRAINAGE

Continued

How does drainage work on a road?



PLAN

ROAD SURFACE DRAINAGE

What is that?

Road surface drainage is the business of getting water off the road.

This is done by making a SLOPING road surface.

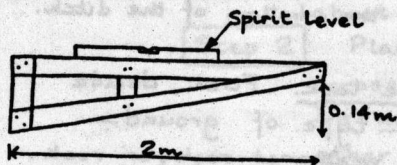
The correct slope must be:

1. Steep enough to get the water to flow off the road quickly,
- and 2. Not too steep (or vehicles will fall in the ditch).

In the LCU we use a slope of 7%
(you say that as "seven per cent")

How do you check the slope?

Slope is checked using a CAMBER BOARD



Put the camber board on the road (cross-wise). Put the spirit level on the top. When the spirit level reads level, the slope is correct.

What does 7% mean?

7% means 7 in 100

Slope is measured by the difference in height for a certain horizontal length.

So 7 in 100 means the slope rises 7 units for every 100 units of horizontal length.

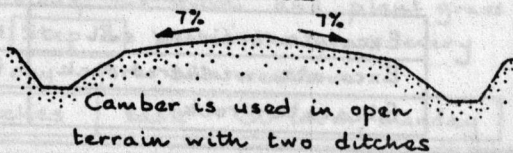
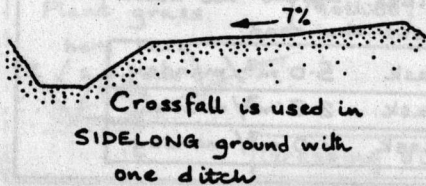


Road shape can be either:

CROSSFALL

OR

CAMBER



DITCHES

Why are ditches important?

Ditches protect a road from water by carrying the water away from the road.

Ditches carry the water from two sides:

1. Water that has run off the road.
2. Water that has run off the hillside: the ditch prevents this water from getting onto the road.

The size and shape of the ditch are decided by the engineer.

A ditch is usually one of the types shown in the Standard Drawings of ditches.

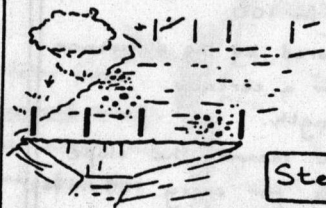
Construction of Ditches

Method

Step 1

The ditch is set out using 4 pegs after formation is completed.

Pegs are set out at the two edges of the ditch and above the two edges of the bottom of the ditch.



Step 2

Set the task. First, decide what is the type of ground—ordinary soil, weathered rock, or rock. Then calculate the area of the cross-section of the ditch. Finally divide the task volume by the area of cross section to give a task as a LENGTH for each manday.

Step 3

Excavate the ditch in two stages: first a furrow the width of the bottom of the ditch and second the excavation of the ditch sides. Spread the material excavated across the road.

Excavate ordinary soil	task	5.0 m ³ /manday
Excavate weathered rock	task	2.5 m ³ /manday
Excavate rock	task	1.0 m ³ /manday

DITCHES _ EROSION CONTROL

What is Erosion Control?

Erosion occurs when the water flows deep enough and fast enough to wash away the bottom of the ditch.

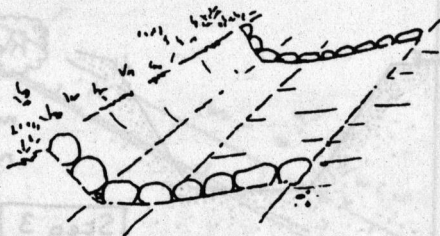
Erosion control is needed as if the ditch becomes too deep the road will collapse into it.

There are several methods of erosion control: the choice of which one is made by the engineer.

Erosion Checks

These are lines of stones across the ditch to prevent the washing away of soil.

They are not walls.



Method

Step 1

Cut a furrow about 0.1 m deep and about 0.2 m wide across the ditch.

Step 2

Place stones (each about 0.2 m across) close together in this furrow. Do not put stones on top of each other — you are not building a wall.

Spacing of Erosion checks:

Very steep hill	> 10%	: 5m spacing
Steep hill	5-10%	: 10m spacing
Gentle hill	3-5%	: 20m spacing
Almost flat	0-3%	DO NOT BUILD EROSION CHECKS!

Instal Erosion Checks

task 20 no./manday

Grassing

Sometimes getting grass to grow in the ditch is a good method of erosion control.

Method

Step 1

Cut a narrow furrow along the ditch and plant grass

Step 2

Water the grass every day for two weeks

Plant grass
here here
here and
here



Grassing ditches

task 30 lin m/manday

DITCHES_ EROSION CONTROL

continued

Stone pitching

Sometimes, in very steep ground or on town roads it is decided to line the ditch with cement masonry

Method

Step 1

Get enough stones collected and bring them to the site.

Step 2

Excavate the trench. Generally the shape is as in the Standard Drawing of ditches.

Remove all loose material from the trench.

Remember

the excavated depth and width must allow for 0.15m thick masonry lining in the ditch.

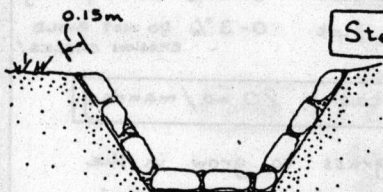
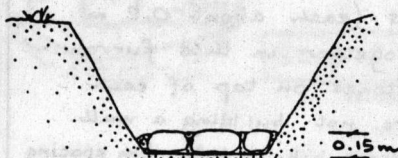
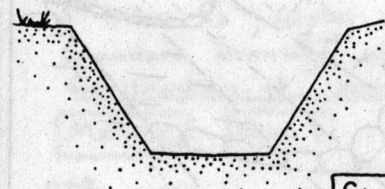
Step 3

Using pegs and string lines lay cement masonry in the bottom of the ditch 0.15m thick. The cement mortar should bind the stones together, but must not cover the stones.

Step 4

Using pegs and string lines build cement masonry along the walls of the ditch, 0.15m thick.

Be very careful that the walls and floor of the ditch are smooth and follow the string lines



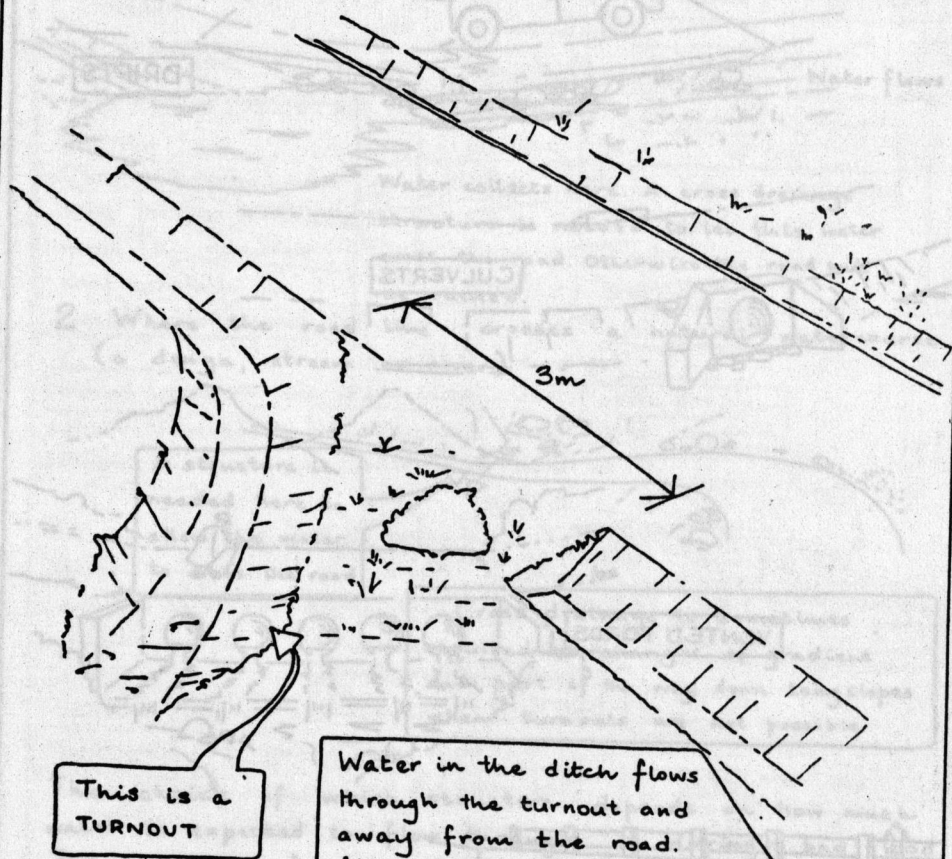
For the stone pitching:

Erect cement masonry 1.0 m³/manday

DITCHES_TURNOUTS

What are turnouts?

Turnouts also called off-shoots are side ditches which are turned away from the road. On a long hill they are needed so that the ditch does not get too full and overflow.



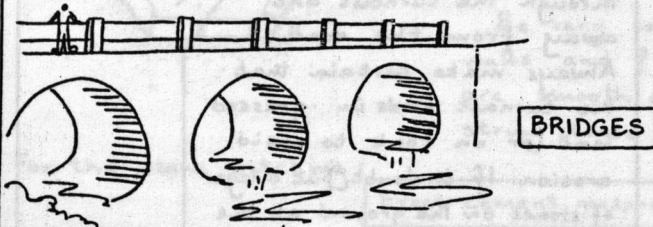
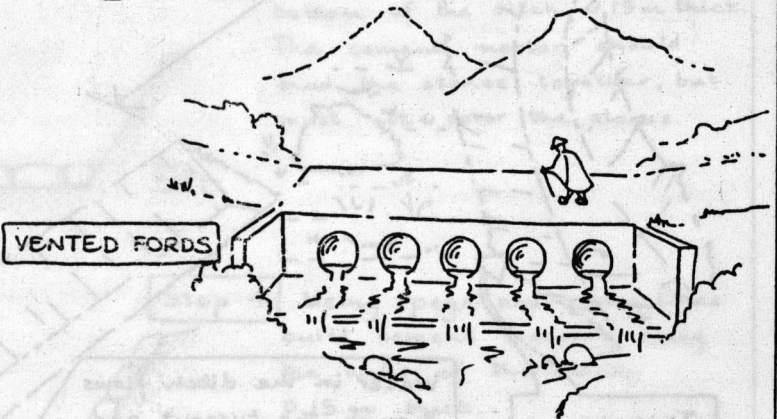
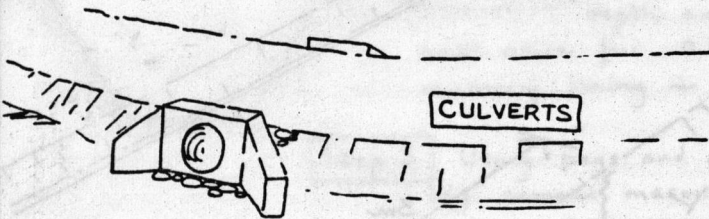
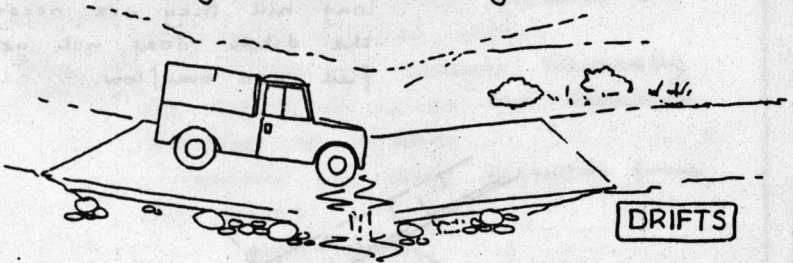
Water in the ditch flows through the turnout and away from the road. Always make certain that the turnout ends in grassed land or on rock to avoid erosion. If in doubt, put a layer of stones on the ground at the end of the turnout.

CROSS DRAINAGE

What is cross drainage?

Cross drainage is any structure which allows water to CROSS the road.

The most common types of Cross Drainage are:

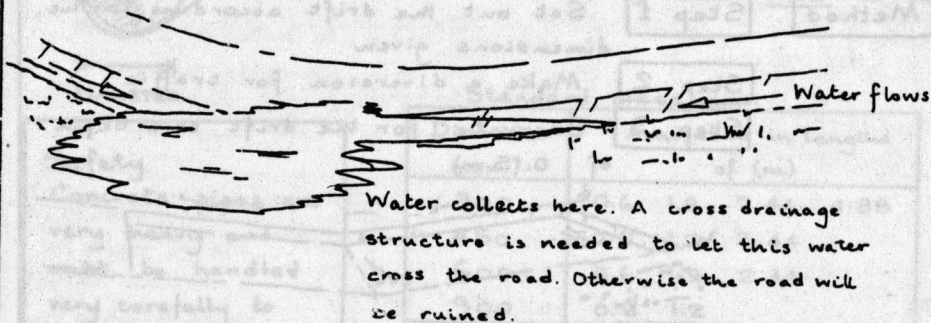


CROSS DRAINAGE

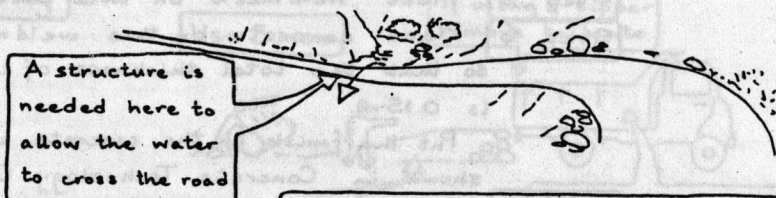
How do you know which structure to put where? continued

A cross drainage structure is always required:

1. At any point where the road and ditch go downhill to that point from BOTH directions.



2. Where the road line crosses a natural watercourse (a donga, stream or river)



Cross drainage is sometimes required at changes of gradient and part of the way down long slopes when turnouts are not possible

The choice of which structure depends on how much water is expected to flow through it during a bad flood. The amount of water depends on the area of land where all the rainwater runs down to the place where the structure is to be built.

This area is called the CATCHMENT

DRIFTS

What are drifts? Drifts are structures which allow water to cross the road on the surface. Because of this they are used only for very small flows of water or where rock makes deeper excavation (for a culvert) difficult.

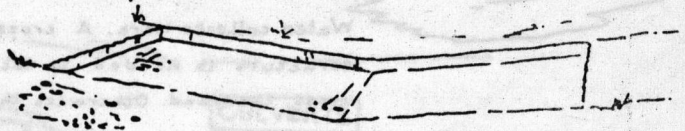
Construction

Method

Step 1 Set out the drift according to the dimensions given

Step 2 Make a diversion for traffic

Step 3 Excavate for the drift to a depth of 0.15 m



Step 4 Place concrete in excavation to a depth of 0.10 m.

Step 5 Place weldmesh on this concrete

Step 6 Place concrete on this weldmesh so that the total thickness of concrete is 0.15 m.

Put the finish on the concrete as shown in Concrete Technology Chapter
Step 7 Cover concrete at the end of the shift with SAND 25 to 50 mm thick.

TIDY UP THE SITE

Step 8 Next day water the sand twice a day. Do this every day for two weeks.

Step 9 TWO WEEKS after the drift has been made brush off the sand (it can be used again if convenient) and OPEN THE DRIFT TO TRAFFIC

Step 10 Close the diversion and remove road signs

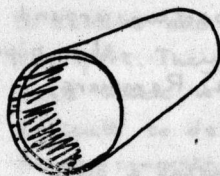
Mix and place concrete task 1.0 m³/manday

CONCRETE CULVERTS

What are concrete culverts?

Concrete culverts are pipes of different diameters made of concrete in certain standard lengths.

These are put together in trenches and covered over to carry water under the road



DIAMETER

Safety

Concrete pipes are very heavy and must be handled very carefully to avoid accidents

Standard sizes are:

Diameter (mm)	Available in Lengths of (m)			
300	0.6	1.2	2.44	4.88
450	0.6	1.2	2.44	
600	0.6	1.2	2.44	
900	0.6	1.2		

Loading

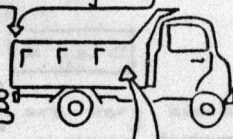
Use 5 men

If using a tipper remove tailgate



Make a ramp of soil with a stone wall so pipes can be rolled onto truck

Tie pipes on securely with rope and wedge with wood or stones

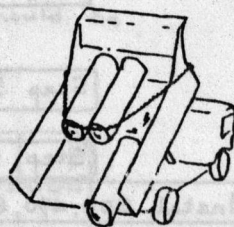


Unloading

If a flat bed truck is used roll the pipes off onto a ramp.
If a tipper is used:

Untie one pipe at a time

Tip on to soft ground.



CONCRETE CULVERTS

continued

Installation

The activity "Instal culvert" includes
 Excavation of trench
 Placing pipes in the trench
 Backfilling and compaction around
 the pipes.

Tools

Crowbars, Pickaxes, Shovels, Rammers



It takes **5** men to instal a 300, 450 or 600 mm diameter culvert of up to 8 metres long



You need a **SIXTH** man for a 900 mm culvert up to 8 metres long

Method

Step 1

Excavate a trench 0.6m deeper and wider (minimum) than the diameter of the culvert.

Step 2

Trim the bottom of the trench so that it is gently sloping in the direction of flow. Now put 50 mm of loose soil over the whole base of the trench - this is bedding for the pipe.

Step 3

Very gently drop the pipes into the trench and using crowbars making the pipes join **PERFECTLY** all round

Step 4

Put back soil into the trench in layers of 0.15m and use rammers to compact this soil.

Step 5

Leave a slight hump of soil about 0.03 m (30 mm) high over the trench.

Step 6

Remove excess soil. **TIDY UP THE SITE.**

Instal 300, 450, 600 mm culvert	task up to /manday
Instal 900 mm culvert	task up to 1.3 m/manday

ARMCO CULVERTS

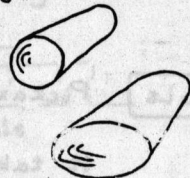
What are Armco Culverts?

Armco culverts are easy to handle and cheap to transport. They are often used when it would be difficult to deliver the heavy concrete pipes to site.

Armco culverts are pipes of corrugated iron which come in parts which have to be put together. They are either:

circular

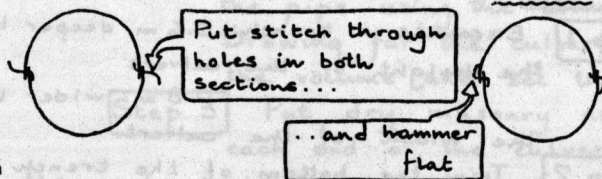
or elliptical



They come in many sizes but here are the ones we use most often.

600 mm diameter circular

These come in two semi circular bits and are joined using metal links called stitches



900 mm diameter circular

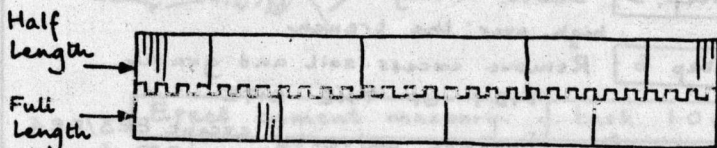
These are very similar to 600 mm pipes but they are bolted together using special bolts and nuts.

Elliptical pipes

These come in two pieces and are bolted together.



To make the culvert the overlap should be done like this for all types:



ARMCO CULVERTS

Continued

Installation The activity "Instal culvert" includes:
 Excavation of the trench
 Assembling the pipes
 Placing the pipes in the trench
 Backfilling with GRAVEL and compaction
 Removal of excavated soil.

Tools Pickaxes, shovels, rammers, hammers or spanners

It takes **5** men to instal an Armco culvert
 up to 600 mm diameter up to 8 m long
 It takes **6** men to instal an Armco culvert
 up to 900 mm diameter up to 8 m long
 It takes **7** men to instal an EE3 or EE4
 elliptical culvert.

Before you start you must have a load of gravel
 delivered to site.

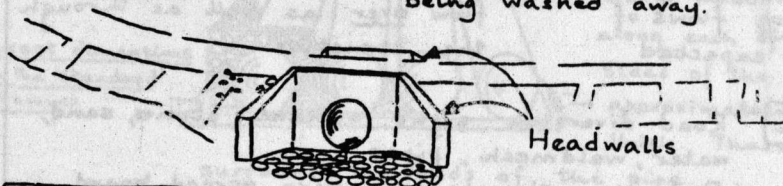
- Method**
- Step 1** Excavate a trench: 0.6 m deeper than
 the height of the culvert
 0.8 m wider than
 the width of the culvert.
 - Step 2** Trim the bottom of the trench so
 that it is gently sloping in the
 direction of flow. Now put about 50mm
 of loose gravel in the whole of the base
 of the trench—this is bedding for the culvert.
 - Step 3** Assemble the culvert and then
 place it in the trench.
 - Step 4** Put GRAVEL in the trench in layers
 of 0.15m thickness and compact using
 rammers. Be CAREFUL not to damage
 the culvert with the rammers.
 - Step 5** Leave a slight hump of about 30mm
 high over the trench
 - Step 6** Remove excess soil and gravel
 TIDY UP THE SITE

Tasks as for concrete culverts except EE3/EE4
 task 0.87m/manday

CULVERT HEADWALLS

What do headwalls do?

Headwalls hold up the soil and gravel at the ends of a culvert and protect the culvert from being washed away.



Materials

Cement, stones, sand, water.

Tools

Mason's trowels, hammers, spirit level, string, shovels.

Method

Step 1

Make certain you have the tools and materials you need.

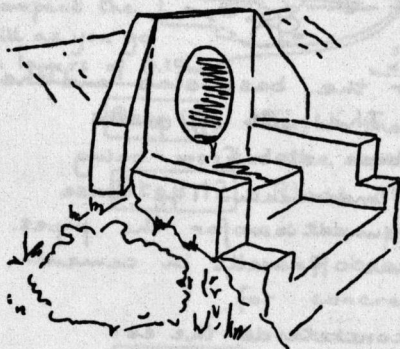
Step 2

Build a cement masonry wall around the pipe using the correct Standard Drawing for the culvert size. Calculate the volume and set the task.

Step 3

Put dry masonry as a floor around each end of the culvert.

If the culvert is flowing into steep ground, some downstream erosion protection may be necessary.



It may have to be as much masonry as this, but the engineer or STO/PTO will decide the exact shape and size. Work like this would be done as a separate activity.

Erect cement masonry

task 1.0 m³/manday

VENTED FORDS

What exactly is a Vented Ford?

A vented ford is needed where large flows of water are expected

A vented ford is a structure where several culvert pipes are surrounded in concrete so that water can flow over as well as through the structure

Materials

Road diversion signs, cement, stones, sand, water, weldmesh, pipes.

Tools

Pickaxes, shovels, crowbars, screed board, mason's trowels, hammers, wheelbarrows, spirit level, string.

Method

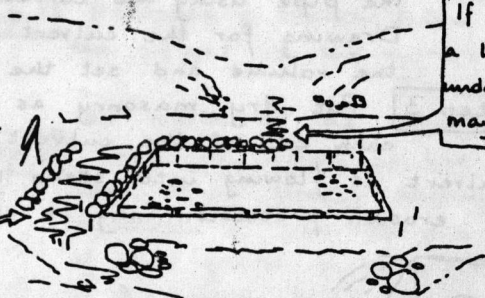
Step 1

Set out the position of the vented ford. (See chapter on Setting Out)

Step 2

Make a diversion for traffic, and put up road signs.

Divert water around excavation



If water flow is a lot, a pipe under the diversion may be used

Step 3

Excavate for the base slab and the cut off walls. The cut off walls protect the base slab from being washed away underneath. The base slab is the foundation for the pipes.

Step 4

Erect the cut off walls in cement masonry.

Step 5

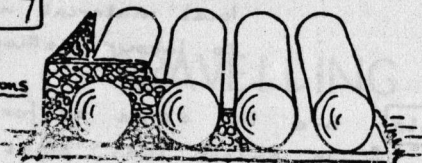
Place the concrete in the excavation for the base slab. Use concrete given in the table in the chapter Concrete Technology.

VENTED FORDS

Step 6 ^{continued} One or two days later, place pipes in position on the base slab at exactly the correct spacing, and perfectly joined.

Step 7

Exact dimensions
on the standard
drawing



Build masonry walls along each of the four sides of the base, approximately 0.5m thick. These walls

surround the ends of the pipe.

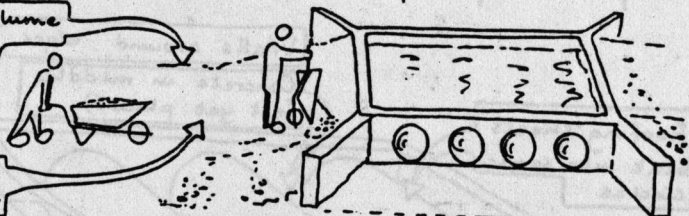
Step 8 Place concrete around the pipes up to the level of the top of the pipes. This is mass concrete so look up the correct mix in the chapter on Concrete Technology.

Step 9 Erect the wingwalls of cement masonry, according to the standard drawing. Cut a furrow at least 0.3m deep as a foundation for these wingwalls.

Step 10 Bring fill to make the road level come up to the level of the deck slab.

Calculate the volume of fill and then give daily tasks

Compact the fill as you go in layers of 0.15m



Step 11 Build the downstream apron according to the standard drawing.

Step 12 Place the concrete for the deck slab over the pipes and level off with the screed board. See "Concrete Technology" for concrete mix. Remember to cure this concrete.

Step 13 After two weeks of curing the deck slab, open the vented ford to traffic.

Remove diversion signs. TIDY UP THE SITE

MINOR BRIDGES

What makes a bridge minor?

These minor bridges are a special type which are not expensive, and use local material well suited to labour methods.

Materials and Tools

are the same as for vented fords except that pipes are replaced by corrugated iron roofing sheets and some timber is needed.

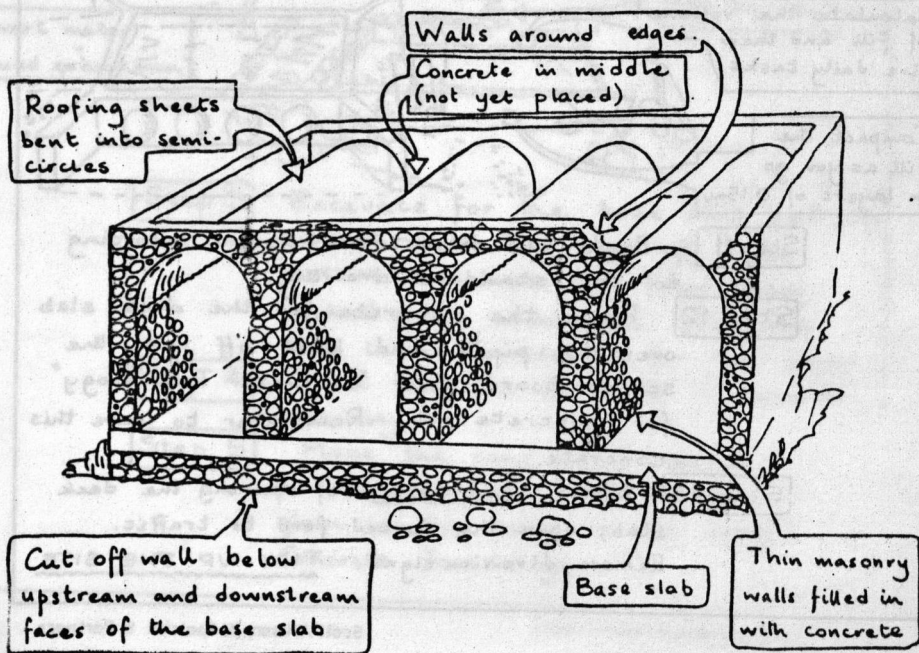
Method

Similar to that for vented ford but it is a bit more complicated.

Because every minor bridge is different further details are not given here. Each bridge must have a sequence worked out by the engineer or PTO/STO.

See Standard Drawing for construction details.

A part-completed minor bridge might look like this:



CHAPTER 5

GRAVELLING

GRAVELLING

What is Graveling? Graveling is the whole process of putting a layer of compacted gravel on a road to make a road passable for traffic in all weathers.

A good gravel is one which is

- STRONG even when wet
- does not wash away
- can be EXCAVATED BY HAND

In Lesotho good gravel is generally obtained from rock called DOLERITE which has been weathered (weakened) by rainwater over thousands of years.

NOT ALL DOLERITE IS SUITABLE.

Finding sources of good gravel is a skilled business and requires experience. TOs and STOs can generally locate good sources but these must be checked by the engineer or PTO who will take samples for testing.

A good gravel needs to have:

STONES FOR STRENGTH

SAND TO FILL THE GAPS BETWEEN THE STONES

CLAY TO BIND THE STONES AND SAND

Very roughly a good gravel should have

50% STONES

40% SAND

10% CLAY

The chapter on soil mechanics gives more details

If there are too many stones and not enough clay:
the gravel will not bind well

If there is too much clay:
the gravel will not be strong
and will be very slippery

GRAVELLING ACTIVITIES

How does the gravelling process work?

Step 1 A place where suitable GRAVEL is found as near to the road as possible. This place is called a QUARRY.

Step 2 This gravel is EXCAVATED and LOADED by hand usually on to TIPPERS.

(If the distance from the quarry to the spreading is less than 200metres, the gravel is taken by wheelbarrow)

Step 3 The tippers then take the gravel ("haul") to where it is needed and tip ("unload") it onto the road.

Step 4 Some men should make sure the shape of the formation is correct (crossfall or camber) before the gravel arrives.

Step 5



The gravel is then spread by hand to the correct thickness.

Step 6 The gravel is then WATERED to achieve good compaction when rolled.



Step 7



The watered gravel is then compacted using a vibrating roller.

Step 8 Finally the shape of the surface is checked using the camber board and any corrections to the shape are made.

QUARRIES

How do you choose a good quarry?

Quarries must always be approved by the engineer or PTO but you should know what makes a good quarry.

GOOD GRAVEL

1 The gravel must be of good quality

ENOUGH GRAVEL

2 There must enough good gravel to make it worthwhile moving to the quarry.

TOPSOIL LESS
THAN 0.3 m.

3 The depth of topsoil should not be more than about 0.3m. If it is more then it will be very expensive to remove it to get out the gravel.

GOOD ACCESS

4 It should be possible to get to the quarry from the existing road or track. If you have to make a road to the quarry this will be expensive.

NEAR TO
GRAVELLING

5 The quarry should be as near as possible to where the gravel is being laid.

LAND NOT
ALREADY
IN USE

6 The land where the quarry is will be spoiled when the quarry is dug. It is better if it is not on farmland or being used to grow vegetables or fruit.

Not all these conditions are always possible to meet. Sometimes it is necessary to choose a quarry that is not ideal

It is VITAL that quarries are found, and tested, and approved LONG before you need them.

QUARRIES

continued

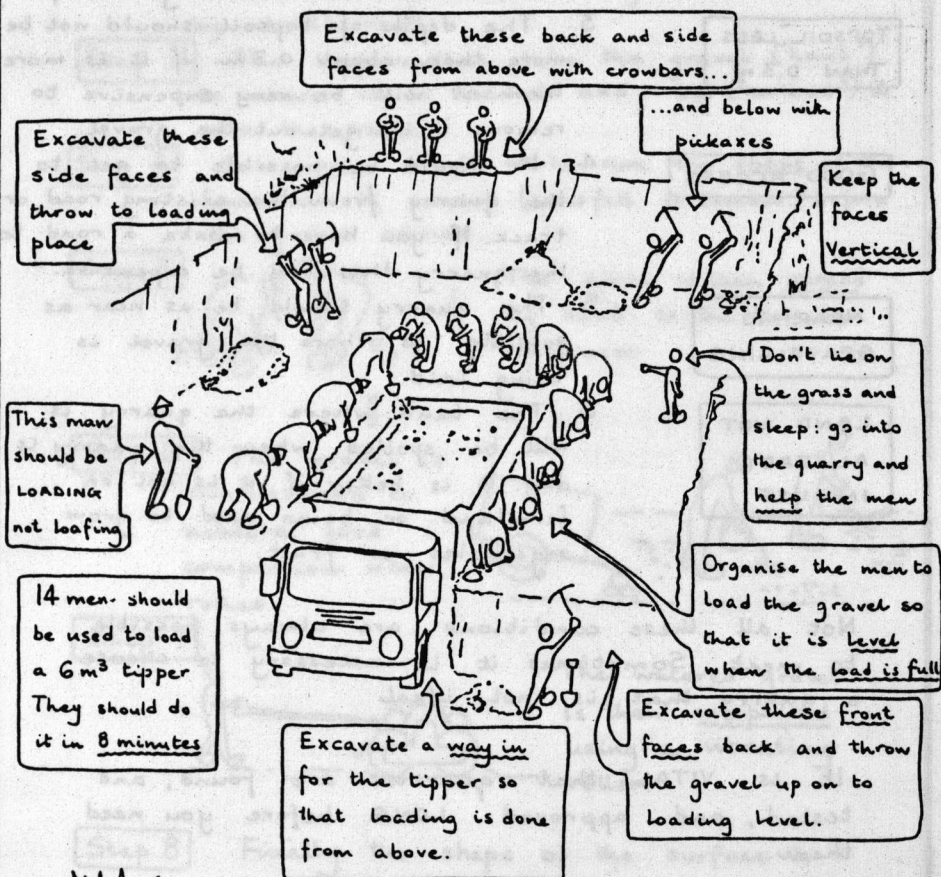
What is the best way to excavate a quarry?

A good quarry means MINIMUM WORK
for MAXIMUM OUTPUT

That is : EFFICIENCY

Tools

Pickaxes, shovels, crowbars.



Never allow the tipper to wait: make certain there is always enough gravel to be loaded.

QUARRIES

continued

How is the quarry organised?

You know how to excavate the quarry to the correct shape. Here are some details on how to organise the quarry and the taskwork.

Each quarry pit should be allocated one tipper which will only go to that one pit.

You should measure the time the tipper spends away from the quarry: that is the time taken from leaving the quarry fully loaded until returning to the quarry ready to be loaded again.

Take several measurements and calculate the AVERAGE. This time is called the JOURNEY TIME.

You should have 25 men in the quarry (except when the journey time is longer than 30 minutes).

This means you will probably need about 30 men in the gang to be certain of having 25 men at work each day.

The TASK in a quarry is a GANG TASK. That means the whole gang is given a task to do together.

You can work out the gang task from this TABLE. It is based on each man doing 2.9 m^3 (in a day) of compacted gravel.

Journey time →	UP TO 15 MINS	15-20 MINS	20-25 MINS	25-30 MINS	30-35 MINS	35-40 MINS	40-45 MINS
Number of men ↓	TASK: Number of loads (6m ³ tipper)						
25	15	14	12	10	*	*	*
24	15	14	12	10	9	*	*
23	14	13	11	9	8	8	*
22	13	12	11	9	8	7	6
21	13	12	10	9	8	7	6
20	12	11	10	8	7	6	6
19	11	11	9	8	7	6	5
18	11	10	9	8	7	6	5
17	10	9	8	7	6	5	5

* These journey times are too long to allow so many men in the pit.

Journey time does not include loading.

Excavate and load gravel task $2.9 \text{ m}^3/\text{manday}$

HAUL AND UNLOAD GRAVEL

Generally, this is done by tippers.

The tipper **MUST**:

- leave the quarry as soon as it is fully loaded.
- drive straight to the spreading gang.

Remember:

The tipper drivers are employed to do what the staff tell them.

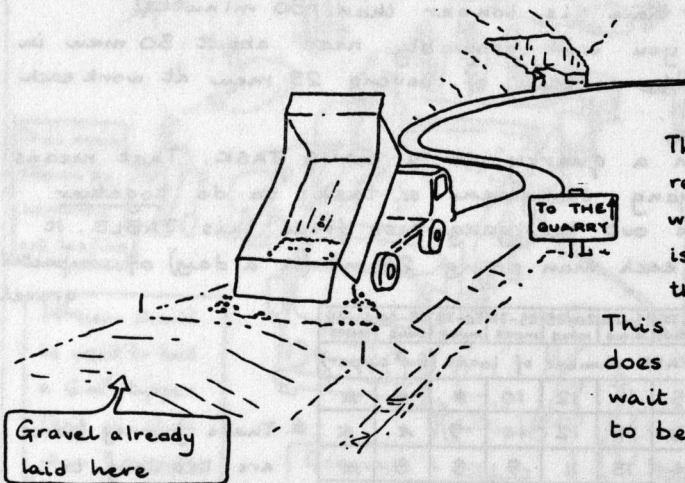
So **BE FAIR**

BE FRIENDLY

But **BE FIRM**

Before the gravel is delivered the formation must be prepared by a gang who checks that the crossfall or camber is correct

Prepare Formation
task 10-20 m/manday



The tipper should reverse to the place where the gravel is needed, facing the quarry.

This way, the tipper does not have to wait for the gravel to be spread.

The tippers must have room to turn **SAFELY**. In mountainous terrain it may be necessary to **EXCAVATE** turning places for the tippers about every 200 metres. This must be done well before the gravelling reaches the place.

SPREAD & COMPACT GRAVEL

DIRECTION OF WORKING

Make certain the formation has been prepared to the correct crossfall or camber

Depending on the number of loads, 10-17 men are needed to spread and shape the gravel

The roller must work all the time: 13 passes over each point

next load will be tipped here

One man is needed to break up the large stones with a hammer

Raking is important good raking gives a good surface

Two to four men are needed to collect and spread the water.

Roller operator is included in the gang on daily records

The finished gravel surface must be as smooth as possible (along and across the road) and to the correct shape

Use camber board and spirit level to check crossfall or camber

Formation ready to be gravelled.

Gravel surface 150 mm thick

Drop one load of gravel every 200m for maintenance at roadside

Spread and water gravel task 15.0 m³/manday

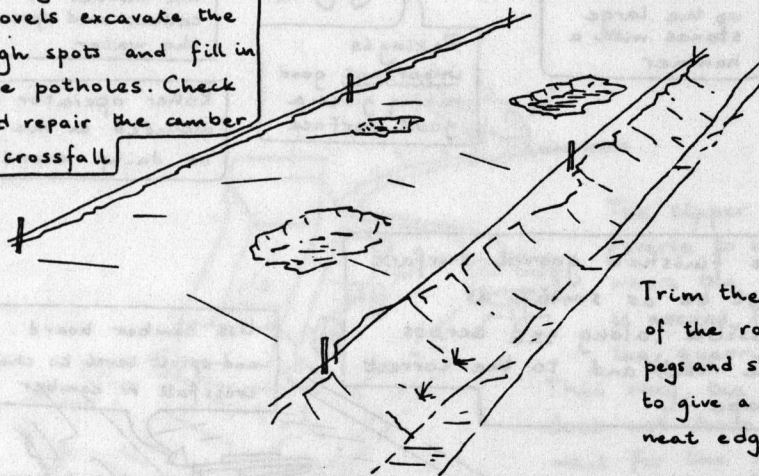
REGRAVELLING

What is Regravelling? Regravelling is gravelling of a road which has been gravelled before but which now needs a new surface of gravel.

When regravelling it may be necessary to clean out ditches and culverts and even replace up to 2 culverts per kilometre of road. Any more work is beyond the scope of regravelling it would be done as ADDITIONAL WORK.

Regravelling is similar in the operations and activities to gravelling EXCEPT:

Using pickaxes and shovels excavate the high spots and fill in the potholes. Check and repair the camber or crossfall.



Trim the edge of the road to pegs and strings to give a straight neat edge.

The gravelling operation must be organised so that there are NO DELAYS caused to the tippers

Make certain a tipper never has to wait for a load of gravel to be spread before it can return to the quarry.

BLACKTOP ROADS

CHAPTER 6

BLACKTOP ROADS

Asphalt is a black, sticky liquid which
dries to a hard, smooth surface. When put on a
road.

Why Do We Use Blacktop Roads?

When a lot of
weight is put on a
ground road, the ground surface
is worn down by the traffic.
This is why we need a strong
road base to support
the weight of the traffic. The road surface
must be strong and hard. It is important to
produce a road that is protected by a hard, smooth
surface.

Ordinary road gravel is made of small stones
which are too small to support the weight of
the traffic. It is too soft to form the road base.
That is why we need a hard, strong surface to
support the weight of the traffic.

The material used for the road surface is called
"blacktop" asphalt.

There are many types of blacktop surfaces.
The one most used is the "hot mix" or
"hot bit" (asphalt and sand).

BLACKTOP ROADS

→ **What are Blacktop Roads?** → They are roads which have a strong foundation (called road base) and a waterproof surface made of a mixture of stones sand and BITUMEN.

Bitumen is a black thick sticky liquid which dries to a waterproof surface when put on a road.

→ **Why make Blacktop Roads?** → When a lot of traffic travels on a gravel road, the gravel surface is worn away by the traffic very quickly. So a strong road base is needed.

The strong road base will support the heavy traffic. Because this strong road base is expensive to produce it should be protected by a waterproof surface.

Ordinary road gravel is often not quite strong enough and is strengthened or STABILISED with LIME (or CEMENT) to form the road base.

LIME is better for hand mixing because it takes longer to go hard.

The waterproof surface is provided by a "blacktop" surface.

There are many types of blacktop surface. The one most used in the L.C.U. is

DOUBLE SEAL (Spray and Chip)

LIME STABILISATION

What is Lime Stabilisation?

Lime stabilisation is the process of mixing lime with gravel to form a strong road base material

Materials

Gravel, the same as gravel for roads
Road lime which comes in pockets of 25kg.

Tools

Shovels, rakes, watering cans, camber board and spirit level.

Safety Equipment

Lime can cause BURNING on the skin and in the eyes.

Everyone working with lime MUST wear this equipment



Goggles

Mask

Overalls

Gloves

Gumboots

Method

Step 1

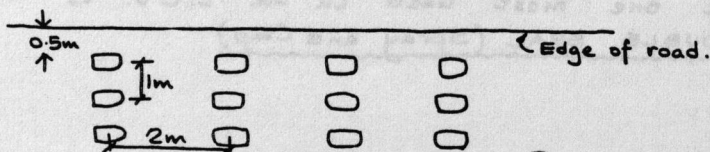
Using pegs, set out the area to be stabilised. The surface should be at the correct crossfall or camber.

Step 2

Tip enough gravel to give a final thickness of 150 mm over the whole area

Step 3

Spread the gravel but do not compact. Lay out the lime bags at the correct spacing. For 4% by weight of lime the correct spacing is a grid of 1m x 2 m.



PLAN

LIME STABILISATION

continued

Step 4 Using shovels, split the bags and spread the lime over the gravel in an even layer. Get the men to work in gangs, in line.

Step 5 Dig through the lime into the gravel and turn this over to mix.



Step 6 Repeat Step 5 two more times. Check the mixture of gravel and lime — if you can see white lumps of lime, mix again until they are gone.

Step 7 Water the gravel well: 1000 litres for 15 m². This is much more than usual and is needed to make the lime work.

Step 8 Leave the gravel to dry out enough so that it can be rolled — this will take one to four days if there is no rain.

Step 9 Using shovels, turn the gravel once again.

Step 10 Roll the gravel. This step is VITAL — have men raking to the correct shape and check every 2 metres along the road with the camber board.

Use **13** passes of the roller.

Step 2	Spread gravel	task* 20 m ³ /md
Steps 3,4,5,6,7	Spread lime + mix with gravel <small>or water</small>	task** 2 m ³ /md
Step 9	Compact gravel	task 20 m ³ /md
Step 9	Compact gravel	task 250 m ³ /rd

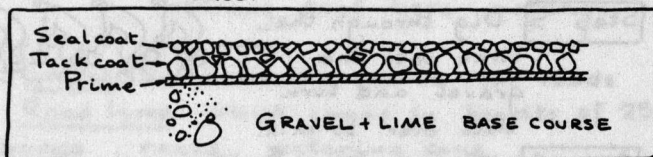
* This is higher than normal as watering is not included.

** This is low to make CERTAIN the job is done properly.

DOUBLE SEAL

What is Double Seal? Double Seal surface dressing is small stones laid in bitumen in two layers on a prepared base.

The finished road in cross section looks like this:



Materials

Prime spray
Spray for Tack and Seal coats
Chips (stones) for Tack coat
Chips (stones) for Seal coat

Prime Spray

Generally MC 30 Prime is used. It comes in 210 litre drums.

You will need about 1.0 litres/m^2

Spray for Tack and Seal Coats

The same spray is used for both coats and is usually PETRAS CATIMARK SPRAY CAT 65%. It comes in 210 litre drums. You will need about 2.8 litres/m^2 in total, that is 1.1 l/m^2 for tack coat 1.7 l/m^2 for seal coat.

Stones for Tack Coat

These are special stones, also called chips, and have to come from a ROADSTONE QUARRY. The size is usually EITHER 19.0 or 13.2 mm diameter.

You will need about 0.008 m^3 of stones for every square metre (m^2) of road.

Stones for Seal Coat

As for tack coat, these are special. The size is usually EITHER 9.5 mm (for 19.0 mm tack coat) OR 6.7 mm (for 13.2 mm tack coat).

You will need about 0.0065 m^3 of stones for every square metre (m^2) of road.

DOUBLE SEAL

continued

Tools and Equipment

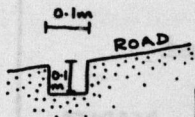
Spraying machine, brushes, watering cans, roller, shovels, pickaxes.

Before you start: CLOSE THE ROAD TO TRAFFIC

Method

Step 1

Along each edge of the road, cut a furrow 0.1m wide and 0.1m deep. This will catch the excess spray and stones and form a tidy, **STRENGTHENED EDGE**.



Step 2

When the gravel road surface is just damp in patches (almost dry), brush the surface clean of dust and loose stones

Step 3

Spray on the prime using a spraying machine. Use a smooth action just slow enough to cover the gravel.

Clean out the sprayer at the end of every shift

Step 4

Next day you can spray on the tack coat. Make certain the stones for the tack coat are ready at the site.

Step 5

IMMEDIATELY spread the stones on the spray using shovels. The stones should cover the spray, but only one stone thick. Roll the surface.

Step 6

Next day, brush off the loose stones and collect them. Allow traffic to run on this surface after 2 days for 1 week.

Step 7

Spray on the seal coat about 1 week after tack coat is laid. Make certain the stones for the seal coat are ready at the site. Spread the stones exactly as for the tack coat one stone thick. Roll the surface.

Step 8

Next day brush off the loose stones and collect them.

Step 9

Open the road to traffic after 4 days

Step 10

TIDY UP THE SITE.

Never spray if the weather looks like rain

DOUBLE SEAL

continued

Activities

Sweep the road using brushes	task 150 m ² /md
Spray prime/tack/seal coats	task 200 m ² /md
Spread stone chips	task 150 m ² /md

Example

Suppose you have a gang of 15 men.

Prime coat: 9 men to cut the furrow and
sweep the road

6 men to collect the drums, prepare
the sprayer, spray and clean up.

Area covered 1200 m² per day

Tack or Seal coat:

Area covered
1200 m² per day

6 men to collect the drums, prepare
the sprayer, spray and clean up.

8 men to collect and spread the
chips

1 roller operator.

Next day: 8 men to sweep the road clean
(You will have to find other work for
the 7 other men).

ROAD MAINTENANCE

CHAPTER 7

ROAD MAINTENANCE



1. District Engineer's Office
2. District Engineer's Office
3. District Engineer's Office
4. District Engineer's Office
5. District Engineer's Office
6. District Engineer's Office
7. District Engineer's Office
8. District Engineer's Office
9. District Engineer's Office
10. District Engineer's Office

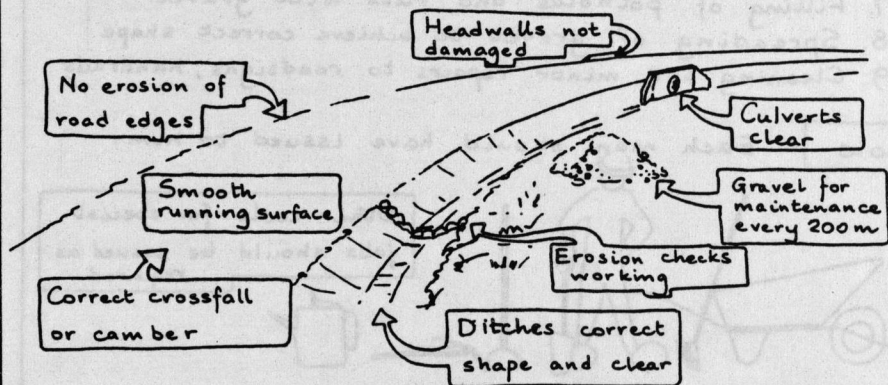
Only District Engineer's Office is shown in this diagram.

ROAD MAINTENANCE

What is Maintenance? Maintenance is the whole business of taking care of a road after it has been built.

To carry out maintenance it is necessary to UNDERSTAND what is required.

When the road is newly built it looks like this:



All these things need work to keep them up to the standard they were in when the road was newly built.

Road maintenance can be divided into three types:

1. ROUTINE MAINTENANCE that is general care of the road as described above.
2. SPECIAL MAINTENANCE this covers work to repair specific damage. Every case is different and must be dealt with individually.
3. PERIODIC MAINTENANCE this is regravelling or resurfacing.

Only ROUTINE MAINTENANCE is dealt with in this chapter

ROUTINE MAINTENANCE

Routine maintenance covers:

1. Cleaning out ditches; removing weeds, silt, rubbish.
2. Reexcavation of ditches to correct size and shape
3. Rebuilding of erosion checks where necessary
4. Cleaning out of culverts and vented fords.
5. Repair of headwalls
6. Protection of road edges where erosion has occurred
7. Filling of potholes and ruts with gravel.
8. Spreading of gravel to achieve correct shape
9. Cleaning and minor repairs to roadsigns, handrails

Tools

Each man should have issued to him:



Other tools for special jobs should be issued as required

- 1 wheelbarrow 1 shovel 1 pickaxe
 1 rake 1 rammer 1 watering can

Method

Step 1

Each section of road, usually 1.5km per labourer, is clearly marked. A man who lives locally is chosen for each section. He is issued with the tools shown and his duties are explained.

Step 2

A senior labourer is chosen for every 10 labourers. He is issued with a bicycle and is responsible for day to day supervision.



Step 3

When transport is available and at least twice a month the TA or TO in charge must visit the road and inspect what has been done, and what is still to be done.

TA or TO checks the tools and replaces any which are damaged

If special or periodic maintenance is required it will be noticed on this trip.

CONSERVATION WORKS

CHAPTER 8

CONSERVATION WORKS

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CONSERVATION WORKS

What are Conservation Works?

Conservation works are any construction which prevents SOIL EROSION, protects AGRICULTURAL LAND and conserves WATER.

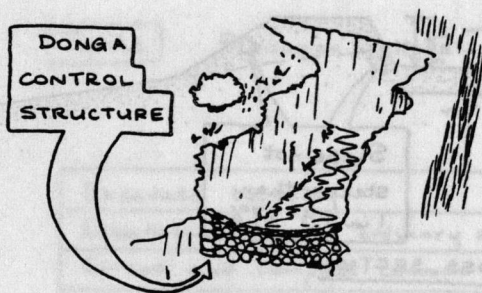
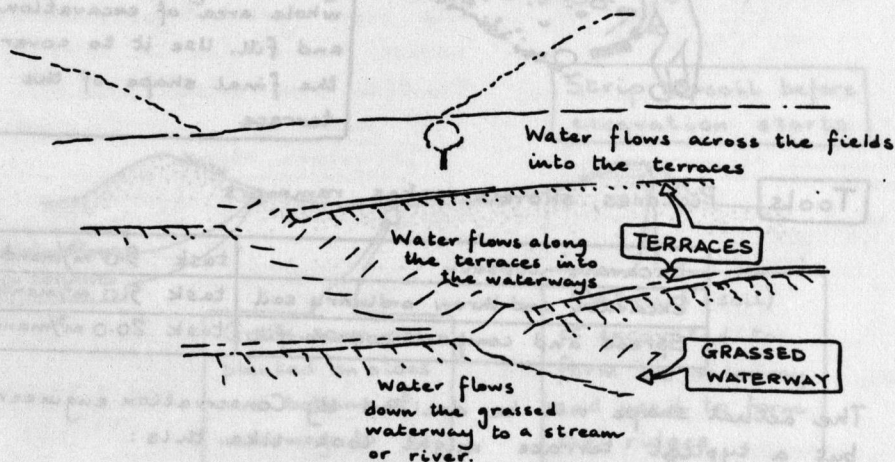
There are FOUR main types

TERRACES or Graded Bunds

GRASSED WATERWAYS

DONGA CONTROL STRUCTURES

SMALL STORAGE DAMS

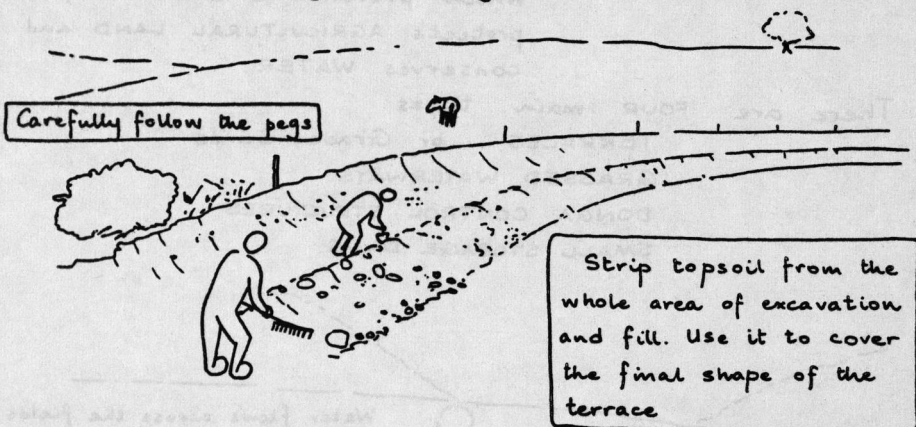


The design of these conservation works is done by conservation engineers and is not covered in this manual. The activities are standard LCU activities and tasks can be set from the chapter on Taskwork and Production Recording.

SMALL STORAGE DAMS are not dealt with in this manual.

TERRACES

Terraces are built across the face of a slope to prevent dongas forming.

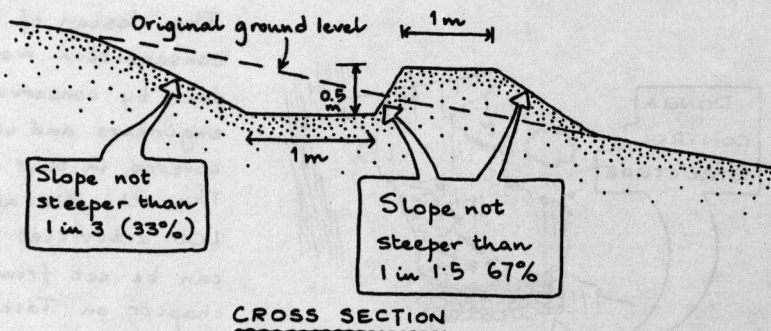


Tools

Pickaxes, shovels, rakes, rammers

Excavate topsoil	task 5.0 m ³ /manday
Excavate and throw ordinary soil	task 5.0 m ³ /manday
Spread and compact common fill	task 20.0 m ³ /manday

The actual shape will be decided by Conservation engineers but a typical terrace might look like this:



GRASSED WATERWAYS

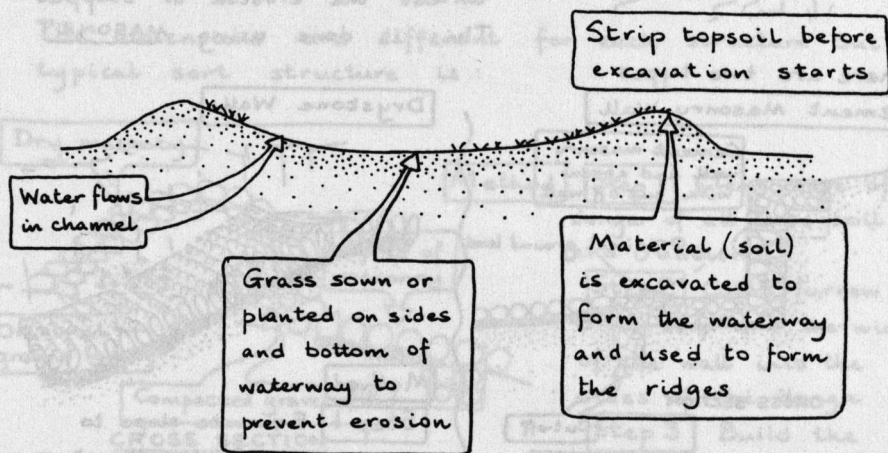
Grassed waterways collect excess water from terraces and carry water down slopes.

They are designed so that DONGAS do not develop.

They must be built before terraces and enough time must pass to allow the grass to take root.

They are usually built between October and April.

Detailed design will be done by Conservation engineers but a typical grassed waterway might look like:



Tools

Pickaxes, shovels, rakes, rammers

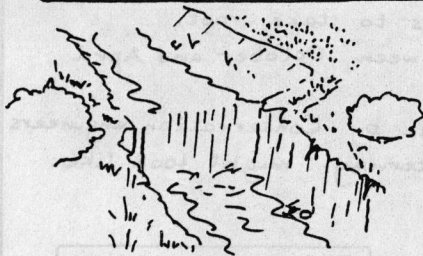
Excavate topsoil	task 5.0 m ³ /manday
Excavate and throw ordinary soil	task 5.0 m ³ /manday
Spread and compact common fill	task 20.0 m ³ /manday

DONGA CONTROL STRUCTURES

There are two types of Donga control structure:

1. Structures at the head of a donga
2. Structures in the bed of a donga.

Structures at the head of a donga



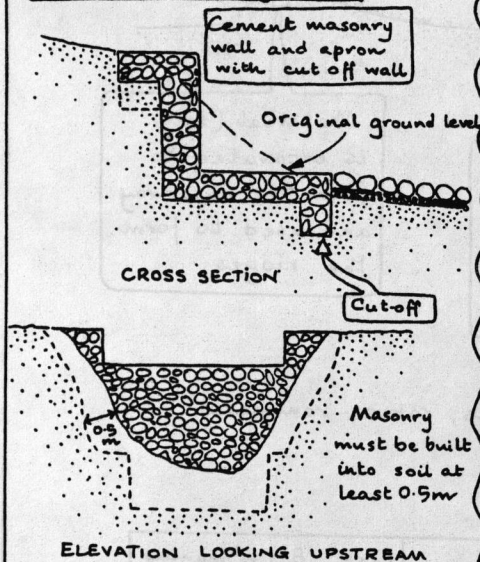
A donga begins when the flow of water is strong enough to wash away the soil.

The head, or beginning, of a donga will move gradually upstream unless the erosion is stopped

This is done using MASONRY

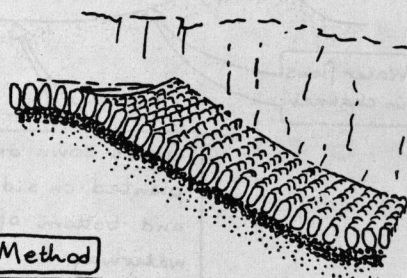
There are two types

Cement Masonry Wall



This method is fairly expensive as it uses cement, which would have to be brought to the site

Drystone Wall



Method

- Step 1** Excavate slope to correct slope for the structure
- Step 2** Place gravel and small stones on this slope
- Step 3** Place LONG, LARGE stones (about 0.5m long) on end close together as shown above.

This method is cheap but requires good stones and good supervision.

DONGA CONTROL STRUCTURES

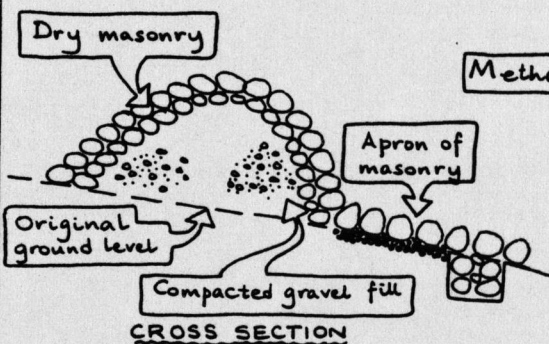
Continued

Structure in the bed of a donga

Structures are placed in dongas to prevent more erosion of the bottom of the donga. The structures trap soil behind them, and grass can grow there which prevents more erosion.

It is better to build a lot of low, small structures along the bed of a donga than to build a few, higher structures

The dimensions are different for each structure but a typical sort structure is:

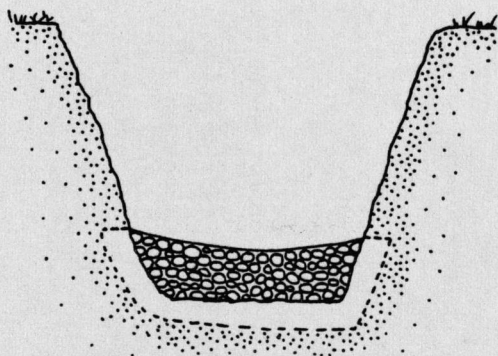


Method

Step 1 Clean base of donga of all loose soil and rubbish.

Step 2 Cut a furrow 0.5m deep and the width of the wall into the sides of the donga

Step 3 Build the structure as shown: gravel fill compacted and surrounded by dry masonry. Remember the sides of the wall should be higher than the centre, to keep the water away from the sides of the donga



ELEVATION LOOKING UPSTREAM

CHAPTER 9

AIRSTRIp WORKS

AIRSTRIp WORKS

Airstrip Works: what does that cover?

Airstrip works cover three things:

CONSTRUCTION

MAINTENANCE

IMPROVEMENT

Construction of airstrips is ideal work for the L.C.U. But because each airstrip is different the subject is not dealt with in this manual.

The engineer will design any construction works

Maintenance of airstrips. This includes:

1. Keeping the runway surface smooth
2. Painting the white runway markers
3. Keeping the ditches clear (and any culverts)
4. Cutting down weeds on runways

Improvement of airstrips. This includes:

1. Making a runway longer
2. Making a runway wider
3. Making a turning circle
4. Making an apron for parking planes
5. Graveling an airstrip
6. Excavating new ditches
7. Installing new culverts
8. Installing windsocks

AIRSTRIP MAINTENANCE

For adequate maintenance, an airstrip usually needs 1 or 2 labourers full time.

Because the airstrips in Lesotho are usually very remote, supervision must be only occasional. That means the TA or TO can only visit each airstrip once or twice a month.

So, he should write down on each visit what things need to be done; and on the next visit he should check that those things have been done.

Tools

Each man should have issued to him:



Method

- 1 Keep the runway smooth
Remove all large stones
Fill in potholes

- 2 Paint the white marker stones when necessary

- 3 Keep the ditches and any culverts clear. Ditches on airstrips are very shallow so that if a plane runs into them it is not damaged. Keep the ditches clear but never make a new ditch unless the engineer tells you

- 4 Cut down tall weeds and grass on grass airstrips and tall weeds at the sides of all airstrips.

Remember always ask your labourers if there are any problems for instance broken tools wrong pay and so on. You are their only contact.

AIRSTRIP IMPROVEMENT

Making a runway LONGER

Making a runway WIDER

Making a turning circle

Making an APRON for planes

All these will probably require EARTHWORKS and DRAINAGE.

Always divide the work into the same ACTIVITIES used in EARTHWORKS and DRAINAGE in Chapter 3 + 4.

Excavate and load ordinary soil

Excavate and load weathered rock

Excavate and load rock

Haul and unload common fill by w/barrow

Haul and unload common fill by animal cart

Spread water and compact common fill

Compact common fill by roller

Install culvert 300 450 or 600 mm dia.

If a gravel surface is required follow the same guidelines as for GRAVELLING in Chapter 5 and use the same ACTIVITIES.

Because each improvement is different, the engineer will give the details for each one.

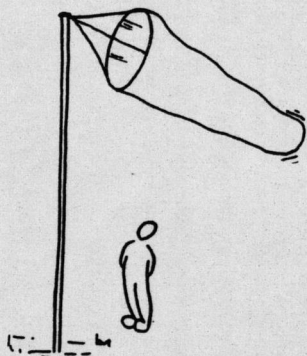
Installing Windsocks

Windsocks are large tubes of canvas which are hung on a pole to show pilots which way the wind is blowing.

They are taken to site in two pieces and assembled at the airstrip.

A TA or TO should always supervise this work.

The location of the windsock is very important - check with the engineer or PTO.



SOIL MECHANICS

CHAPTER 10

SOIL MECHANICS

THE SOIL'S PROPERTIES

GRAVITY

Almost all soils are in a state of partial freedom to the movement of the different particles (by weight) of soil mass. That is how much gravity how much soil mass can be made to move in a soil.

PLASTICITY

This property of soil is the strength of soil may be called plasticity. The amount of soil in a soil is plasticity.

DENSITY

The mass of a soil is the density. It will be. The amount of water in a soil has a big effect on how dense it can be.

SOIL MECHANICS

What is Soil Mechanics? Soil mechanics is the SCIENCE of how soil (ordinary soil, weathered rock, sand, gravel, and stones) behaves and whether it is suitable for various uses.

For instance Soil mechanics is used to discover:

- is a gravel good enough for a gravel road surface?
- is a particular soil good enough for use as fill?
- what is the best way to compact a particular soil?

As with all science, a few BASIC PROPERTIES are found out using STANDARD TESTS.

The main thing about standard tests is that the same test is done on different samples and so those samples can be compared. With experience results from these tests will tell you what the soil is like.

As a first step a soil is inspected at the site using FIELD TESTS as indications of the BASIC PROPERTIES.

THE BASIC PROPERTIES

GRADING

Almost all soils contain various sizes of particles. Grading is the measurement of the different amounts (by weight) of each size. That is how much stones? how much sand? how much silt? how much clay? in a soil.

PLASTICITY

This gives an idea of how strong the soil may be and how well it can be compacted. The amount of clay in a soil affects plasticity.

DENSITY

The more dense a soil is the stronger it will be. The amount of water in a soil has a big effect on how dense it can be.

FIELD TESTS

- What are field tests? These are very simple tests on soils which require no special equipment.
- What are you looking for? You are looking for the soil properties which will tell you what the soil is useful for.

For ROAD GRAVEL you want stones mixed with sand, for strength, and with some silt and clay to bind it together.

For FILL you want to make sure there is some clay but not too much. There can be stones but there don't have to be.

For SAND and STONE for concrete you want to make sure there is no clay in the material.

For ALL SOILS you want to make sure there is no organic material.

Take a handful of soil and wet it.

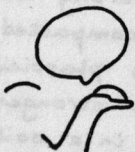
First of all, get close to your sample

SMELL



If it smells at all it probably contains ORGANIC MATERIAL and so is no good for road building.
If it does not smell it is probably okay.

LOOK



What colour is it? If it's black it may be difficult to work with in the rain.
If your hands are muddy, the soil contains silt and clay.

FEEL



Rub the soil between your fingers. You will be able to pick out the largest pieces.
If they are bigger than 2mm they are gravel size.
If the soil feels greasy it is almost all silt and clay.

FIELD TESTS

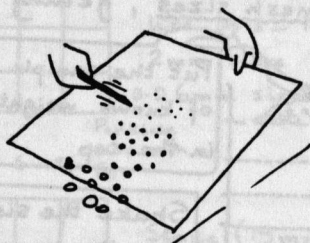
continued

VIBRATION TEST

This is a simple test which roughly separates the different sizes of particles in a soil.

Put a handful of dry soil on a piece of cardboard. Lift one end slightly and tap the board gently.

If there are particles of most sizes, the soil should be alright for fill but no good for concrete if there is silt or clay.



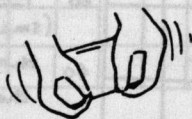
SETTLING TEST

Another simple test to separate roughly the different sizes of particles in a soil.

Put a handful of soil in a glass jar. Fill the jar with water $\frac{2}{3}$ full.

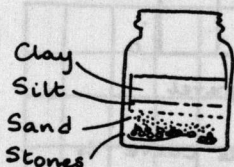


Shake the jar violently



Put the jar down again. The water will gradually clear to show the coarsest particles at the bottom and the finest, the clay, will still be mixed with the water.

A rough idea of how much of each size of particle is got from this test.

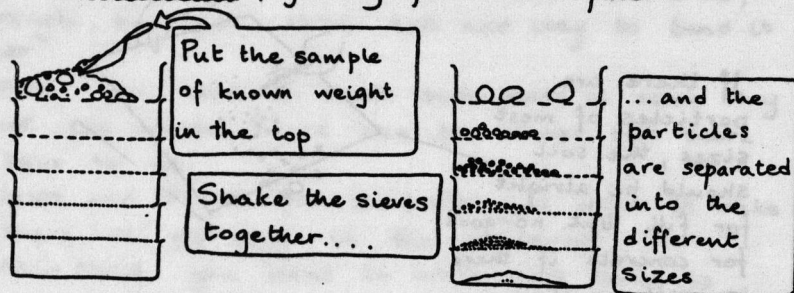


GRADING

What is Grading?

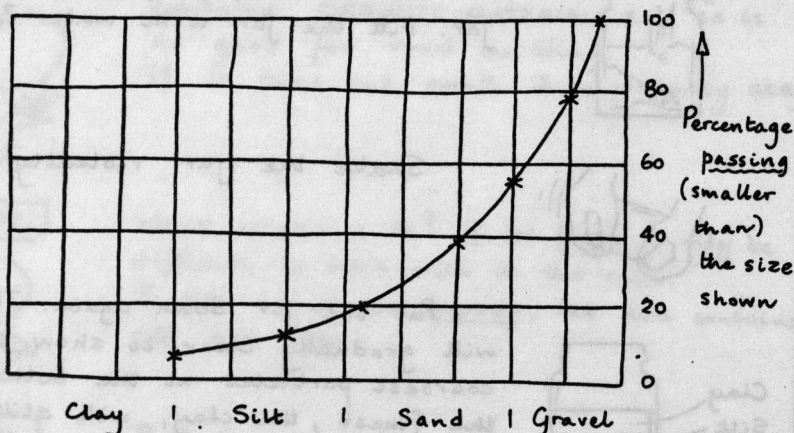
Grading is the measurement of the different amounts of each size of soil particle in a soil sample.

In the soils laboratory it is measured by shaking a known weight of soil through SIEVES of different mesh sizes, getting finer and finer.



CROSS SECTION

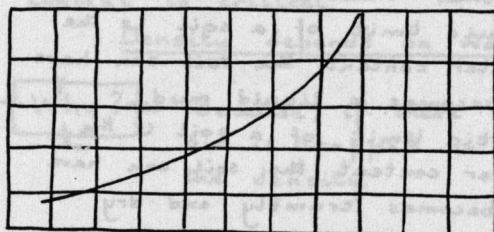
By weighing the whole sample and then weighing the amount held by each sieve, the percentage or fraction of the total which passes each sieve can be drawn on a graph



In this way a curve, called a GRADING CURVE is produced. Different soils, of course, have different grading curves.

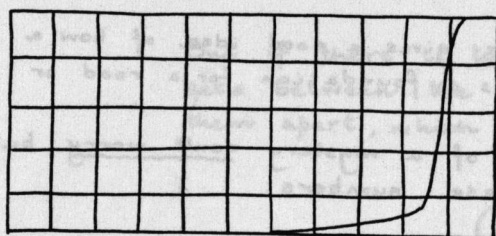
GRADING CURVES

Here are some typical grading curves for various materials.



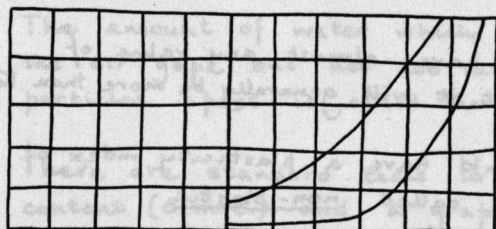
Fill or ordinary soil with no gravel size particles in it would look very roughly like this - 100% passing the 2mm sieve 50% passing the 0.06mm sieve and so on.

Particle
size mm



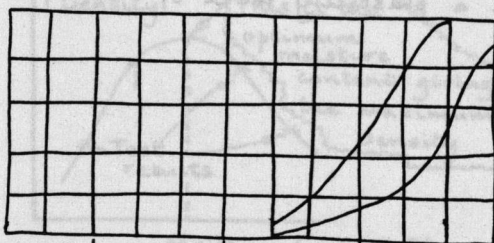
Stone (19mm) from a crusher (like Lesotho Crushers) would have a grading like this - almost all the material passes the 20mm sieve and almost none passes the 6mm sieve.

CLAY | SILT | SAND | GRAVEL



Road Gravel. If a sample of gravel is tested and its curve falls between these two lines it is acceptable in its grading.

.002 .06 2 6 20 60



River sand and gravel for concrete. If a sample of material is tested and its curve falls between these two lines, its grading is acceptable

CLAY | SILT | SAND | GRAVEL

PLASTICITY

What is Plasticity?

Plasticity is measured by the Plasticity Index of a soil. The Plasticity Index is Liquid Limit minus Plastic Limit.

Liquid Limit

The liquid limit of a soil is the highest water content the soil can have before it becomes a liquid mud.

Plastic Limit

The plastic limit of a soil is the lowest water content the soil can have before it becomes crumbly and dry.

So, Plasticity Index is the range of water contents where the soil is workable: not too dry and not too liquid and muddy.

As it happens this index gives a good idea of how a material will behave as a foundation for a road or a runway.

IF all this is a bit of a mystery don't worry, but try to remember these numbers:

Road gravel should have a plasticity of between 6 and 12

Ordinary soil can have almost any value of plasticity index but it will generally be more than 12.

Sand or stones would have a plasticity index of zero — it would be called non-plastic.

Clay used for plastering the village houses in Lesotho would have a plasticity index of about 30.

DENSITY

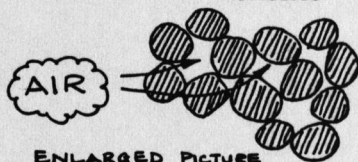
The more dense a soil can be made, the stronger that soil will be.

To achieve maximum density possible, the water content is critical.

Density depends on water content.

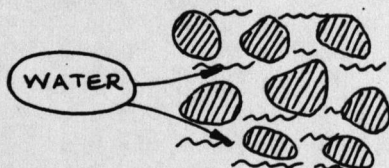
Why?

Because, if there is not enough water, air is trapped in the soil and reduces the density.



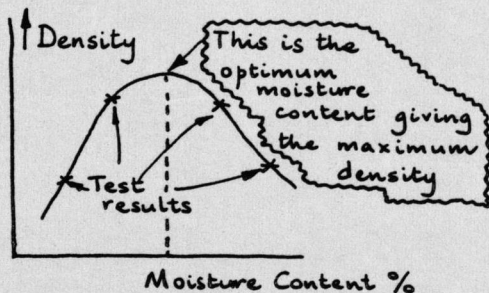
ENLARGED PICTURE

But if there is too much water, the water gets between the soil particles and keeps them apart, which also reduces the density.



The amount of water which is just enough to fill the air gaps but not too much to keep the soil particles apart is called the OPTIMUM MOISTURE CONTENT

There are standard tests to find the optimum moisture content (o.m.c.) and a graph is drawn from the results:



All you need to know is what is the o.m.c. in %, so that you can calculate how much water to add to your gravel or fill for good compaction.

CONCRETE TECHNOLOGY

CHAPTER 11

CONCRETE TECHNOLOGY

Stone and sand are needed for concrete. Cement and water are added to bind together the stone and sand.

Stone

Sand



Cement

Water

When concrete is mixed, the cement reacts chemically with the water and gradually hardens and dries as time goes on. It goes on needing water for some time to cure and as kept available at the surface.

CONCRETE TECHNOLOGY

What is concrete?

Suppose you need something strong like rock, which will not be washed away or broken down. A rock of the right size and shape would be impossible to find

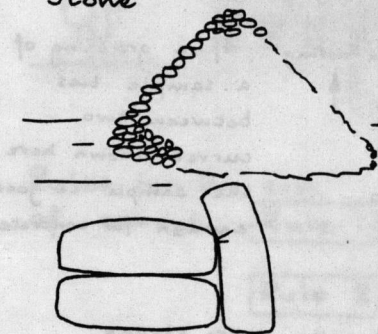
CONCRETE IS MAN-MADE ROCK

It can be poured into any shape when it is wet and then it goes as hard as rock.

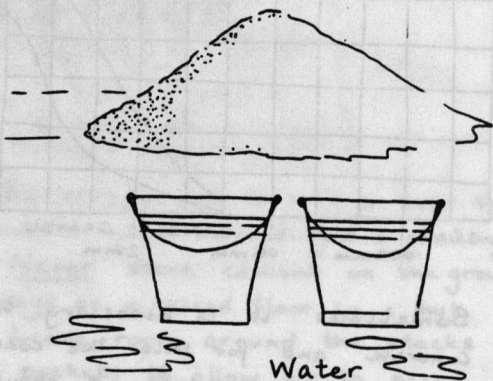
Stone and sand are needed for STRENGTH
Cement and water are needed to bind together the stones and sand.

Stone

Sand



Cement



Water

When concrete is mixed, the cement reacts chemically with the water and gradually gets harder and harder as time goes on. It goes on needing water for a LONG TIME so water must be kept available at the surfaces.

CONCRETE MATERIALS

STONE and SAND



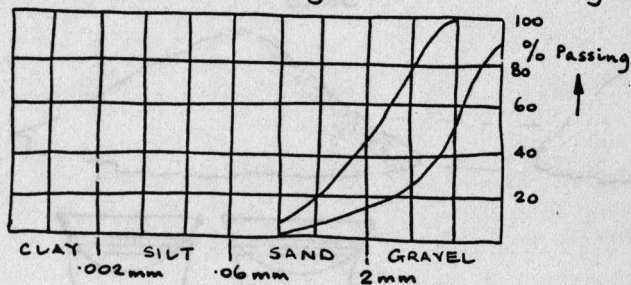
Stone and sand together are called **AGGREGATE**

Stone is **COARSE AGGREGATE**

Sand is **FINE AGGREGATE**

Very often in the LCU, sand and stone from a river bed is good enough aggregate for concrete.

Aggregate for concrete should have no silt or clay and at least two thirds (by weight) should be bigger than 2mm diameter (gravel size, coarse aggregate). This should always be checked by a grading test.



If a grading of a sample lies between two curves shown here the sample is good enough for concrete.

Sometimes it is necessary to make extra strong concrete and for this the coarse aggregate is bought from a crushing plant. It should be 19mm aggregate. The fine aggregate would then be sand.

Never use aggregate which contains:

SHELLS, because they are weak and crush.

SILT AND CLAY, because the concrete cannot mix well.

ROOTS AND WEEDS, because they will rot and split the concrete.

CONCRETE MATERIALS

CEMENT

Cement has to be bought and is relatively

VERY EXPENSIVE so it must be kept secure.
Cement reacts chemically with water so it must be kept dry

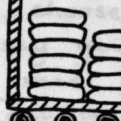
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Keep the cement secure - use a watchman



Stack the pockets neatly



Keep the hut locked

Stack away from the wall



Erect hut on stones or creosoted poles to prevent water coming in

Rules for the care of cement

Rule 1 Be careful not to split or tear the pockets when unloading and stacking.

Rule 2 Never store cement on the ground, always on a raised floor in a hut.

Rule 3 Leave room around the stacks of pockets to allow air to pass. Stack neatly

Rule 4 Keep the cement store securely locked and guarded at all times.

WATER

Remember

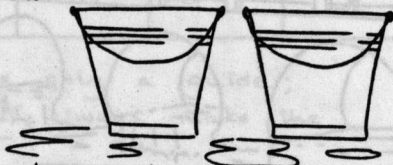
Not much to say but it is **IMPORTANT**

NO MUD

NO FISH

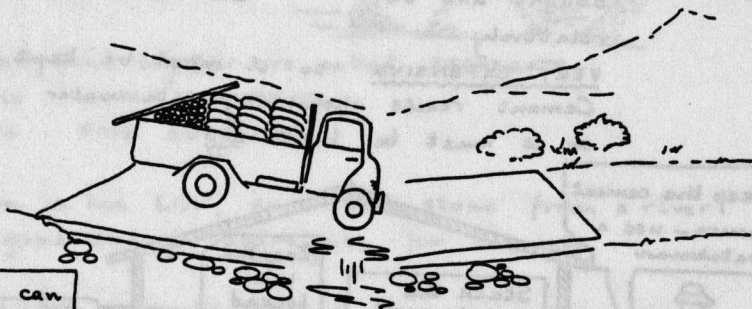
NO FILTH

which means: always use clean water.



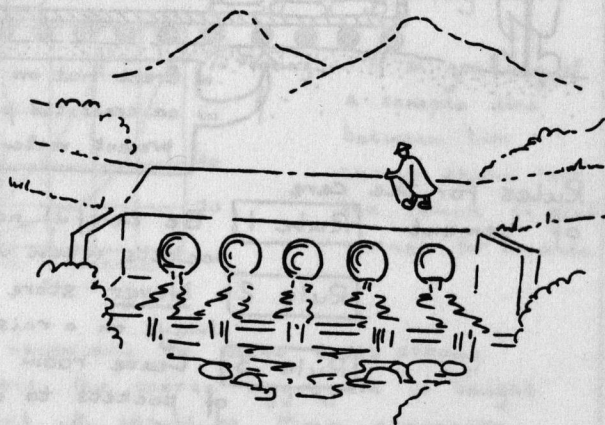
USES OF CONCRETE

Where do you use concrete? Concrete is used where strength is needed.



Concrete can resist water

Concrete can carry heavy loads on it without breaking



Good concrete lasts for many years



CONCRETE MIXES

How do you make concrete? You must first decide on the mix

That is to say

- how much STONE (Coarse aggregate)
- how much SAND (Fine aggregate)
- how much CEMENT
- how much WATER

Remember sometimes stone and sand are dug from the river bed together and this is called aggregate.

This TABLE below gives you the different quantities you need for different parts of structures.


First, choose the type of concrete you want (let's say you are making concrete for a drift). Then read along the line for that type to find out the quantities of cement, aggregate and water that you need.

Where concrete is to be used	Concrete mix				
	pockets of cement	w/barrows of river sand + gravel	w/barrows of sand	w/barrows of 19mm stone	litres of water
Base slabs, deck slabs, drifts	10	30	-	-	250
Mass concrete around vented ford pipes, bridge arches	10	40	-	-	250
Piers of minor bridges	10	-	10	20	250
Lean mix for bulk fill up to foundation slab level etc.	10	60	-	-	300

Remember: these mixes are only a guide; the engineer will always make the final decision.

MIXING CONCRETE

Now you know the mix quantities.
This is how you make the concrete.

- Method**
- Step 1** Choose a clean hard flat area to work on.
 - Step 2** Put the exact quantity of aggregate on the mixing area and make it into a circle
 - Step 3** Put the exact number of pockets of cement around the inside of the circle and open them. 
 - Step 4** Mix the cement and aggregate by turning them over with shovels.
Do this **THREE TIMES**
 - Step 5** Gradually add the water and make certain it does not run away. Keep turning the dry mixture into the wet mixture with shovels
 - Step 6** When all the water is added turn over the mixture with shovels
Do this **THREE TIMES**.
The concrete is now ready to place



The WATER must NOT be more than the amount shown on the previous page.

WATER CONTENT IS CRITICAL



Example If, instead of 250 litres of water, 350 litres were used, the final strength of the concrete would be HALVED.

Make certain you add the correct amount of water.

PLACING CONCRETE

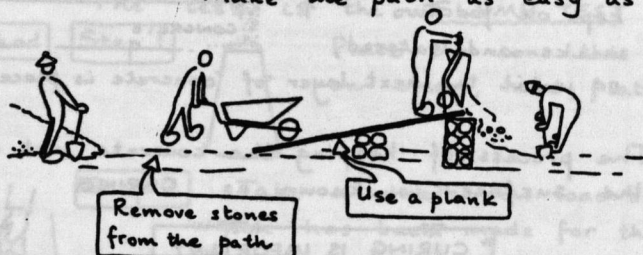
Now you have made the concrete
This is how you place it in the structure.

Method **Step 1** The concrete must be placed within
half an hour of being mixed

Do not allow the
concrete to stand
before it is placed.

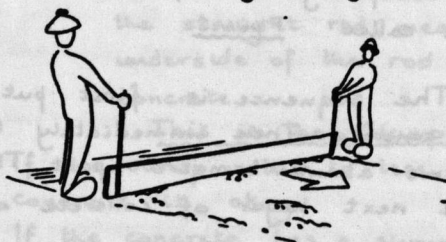


Step 2 Haul the concrete by wheelbarrow.
Make the path as easy as possible.



Step 3 As the concrete is tipped into place
it should be compacted using a length
of steel bar. This is important to get
rid of all the air.

Step 4 On deck slabs and drifts, and on
foundation slabs, the surface is made
smooth by using a screed board



The board is
moved up and
down on the
concrete and slowly
moved over the surface

PLACING CONCRETE

continued

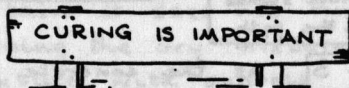
Step 5 If at the end of a shift, the concrete is not to the top of the structure, the surface of the concrete must be made rough by brushing after about 2 hours.

Step 6 Whenever concrete is placed the surface must be covered with wet sand to prevent evaporation of the water, which makes the concrete weaker.

The sand must be kept on for two weeks and watered, or until the next layer of concrete is placed.



The process of keeping the concrete wet at the surface is known as CURING



PLUMS In lean mix and mass concrete, the volume of concrete can be increased by using large stones dropped into the wet concrete when it is in place

These large stones, about 400 mm diameter, are called PLUMS

The sequence is: first put in a layer of concrete. Then immediately throw in plums about 1 metre apart. Then put in the next layer of concrete and so on.

Do not put plums in concrete for deck or base slabs, drifts, or bridge piers

SLUMP TEST

What is a Slump Test?

Concrete needs to be tested to make sure it is going to be strong enough.

There are two times to test concrete:

1. when it is wet, before it sets
2. when it is hard, after it sets.

1. When it is wet. To test concrete when it is wet, you are really testing to see that there is not too much water in the mix

The test is the SLUMP TEST

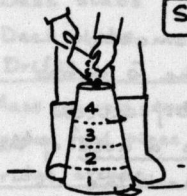
Method

Step 1



Place the cone this way up on clean, hard, flat ground

Step 2



Take a wheelbarrow load of concrete which has been made for the structure. Using this concrete, fill the slump cone in four, roughly equal, layers.

Compact each layer with 25 strokes of the tamping rod.

Smooth off the top of the cone

Gently remove the cone from the concrete. The concrete will slump.

Turn the cone upside down and using the straight rod measure from the underside of the rod to the top of the concrete.

This is the Slump Value

This is the slump value

Step 3



Results

If the slump value is less than 100 mm, the concrete is okay.

If the concrete has a slump value of more than 100 mm, it will be too weak.

Add 2 pockets of cement for 40 wheelbarrows of aggregate, mix in and test again. If the slump is still more than 100 mm throw the concrete away. Use less water in the next mix.

CUBE TEST

What is the Cube Test? The cube test is a standard way to test concrete when it is hard.

The test is done by making concrete cubes of a standard size in a standard way and then finding out what force is required to crush them after 1 week, 2 weeks and 4 weeks.

The equipment required is 6 cube moulds and a rod.

Method **Step 1** Check the moulds are clean, lightly oiled and firmly fixed to the baseplate.



Step 2 Take a wheelbarrow load of concrete which has been made for the structure. Using this concrete fill the moulds each in three equal layers. Compact each layer with **35** strokes of the tamping rod.

Step 3 Remove surplus concrete and smooth with a mason's trowel, each of the 6 cubes.

Step 4 With a nail, scratch an identification mark on each cube and make a note of the mark, the date, the structure, and the position of the concrete in the structure

Step 5 Cover with a damp cloth and store inside overnight.

Step 6 Next day: loosen the nuts on the mould and gently remove the cube from the mould. The cube is very weak at this stage so be gentle

Step 7 Take the cubes to the laboratory and make certain they are put in a tank of water

Make sure the laboratory has an order to crush the cubes
 2 after 1 week
 2 after 2 weeks
 and 2 after 4 weeks

CUBE TEST RESULTS

What results should be expected from crushing the cubes?

The tests will report a STRENGTH probably in units of Newtons per square millimetre written N/mm^2 .

Here is a TABLE of MINIMUM strengths which are acceptable, and the strengths which the concrete mixes are designed to give.

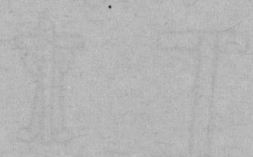
Where concrete is to be used	Concrete mix					Ratio* cement: aggregate	Design Strength N/mm^2	Minimum Strength N/mm^2
	pockets of cement	w/barrow of sand + gravel	w/barrow of sand	w/barrow of 19mm stone	litres of water			
Base slabs Deck slabs Drifts	10	30	-	-	250	1:6	20	15
Mass concrete around vented ford pipes, bridge arches.	10	40	-	-	250	1:7½	15	10
Piers of minor bridges	10	-	10	20	250	1:2:4	25	15
Lean mix for bulk fill up to e.g. foundation slab level	10	60	-	-	300	1:10	7	5

* 1:6 means 1 part cement
mixed with 6 parts sand + stone aggregate
1:2:4 means 1 part cement
mixed with 2 parts sand
mixed with 4 parts stone
measured by volume

SETTING OUT

CHAPTER 12

SETTING OUT



SETTING OUT

What is setting out?

Setting out is the marking on the ground of what is to be built.

So: if a road is to be built there are pegs to show the position and width of the road;

if a bridge is to be built there are pegs and boards to show the position and width and level of the bridge.

Equipment

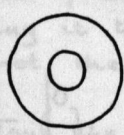
Tape measures



3 metre



10 metre



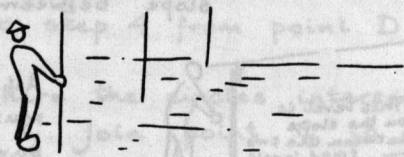
30 metre

String or mason line

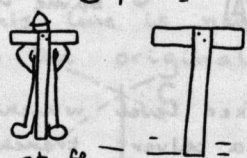
Pegs and hammer

- Blue pegs for level
- Red pegs for excavation/fill
- White pegs for centreline
- Green pegs for offsets

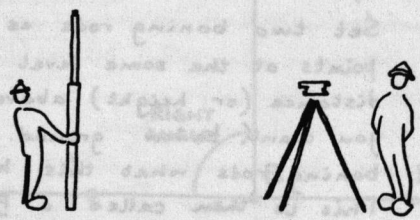
Ranging Rods



Boning Rods



Level, tripod and staff.



SETTING OUT METHODS

TAPE MEASUREMENT

Check the beginning of the tape is actually zero—some old tapes have lost a bit. If the tape does not start at zero the readings will be nonsense.

Hold the tape straight and tight. When measuring length or width hold the tape horizontal.

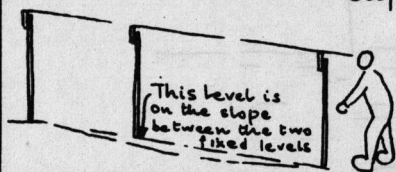
RANGING RODS

Ranging rods are for setting out straight lines. You must have two rods at fixed positions which give the line. Then use a third (and maybe a fourth) rod to give other points along the line.



BONING RODS

Boning rods are for levels. If you have two fixed levels you use a boning rod to find a point on the slope between those two levels.



All three boning rods must be exactly the same length.

If you have a fixed level which is below ground, say the bottom of a culvert trench, which you want to set out:

Set two boning rods as fixed points at the same level a known distance (or height) above the level you want below ground. Mark on the boning rods what this height is. This is then called a PROFILE.

SETTING OUT METHODS

continued

SETTING OUT A RIGHT ANGLE

You need right angles to set out structures such as drifts, vented fords, and bridges

Equipment

Pegs, string

Method

Step 1 You must have a straight line to start with. From this line you set out the right angle. Take a piece of string very roughly 5 metres long.

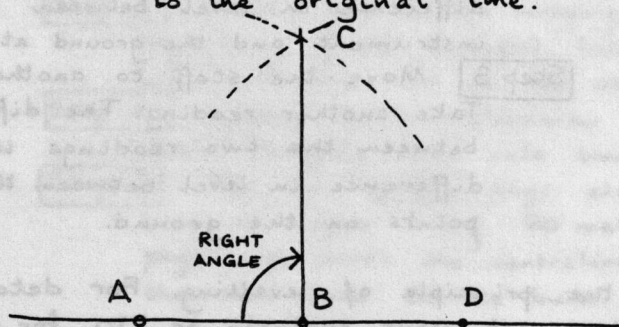
Step 2 By holding the two ends of the string together, and pulling it tight, find and mark with a knot the middle of the string.

Step 3 Lay out the string along the straight line with the middle (the knot) at the point you want the right angle (point B on the diagram). Put in a peg at each end of the string (points A and D)

Step 4 Hold one end of the string at A and mark on the ground the circle the string makes

Step 5 Do step 4 from point D

Step 6 Where the circles intersect is point C. Join point C to point B. This line is now at right angles to the original line.



SETTING OUT METHODS

LEVELLING

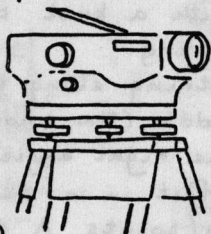
Continued
 Levelling is any method which allows you to look along a level or horizontal line.

Boning between two points of the same level is levelling but there is a more accurate method.

Equipment

A level, tripod and staff (usually).

The level is usually a QUICKSET which is fixed to the tripod. The staff is just a tape painted on a piece of wood in a special way.



Tripod
(top part)



Method

Step 1

Set up the level. You will have to be shown how to do this: it cannot be explained in a book.

Step 2

The level is now set up so that if you look through it, you are looking along a horizontal line. Put the staff on a point. The reading is the difference in level between the instrument and the ground at the staff.

Step 3

Move the staff to another point. Take another reading. The difference between the two readings is the difference in level between the two points on the ground.

This is the principle of levelling. For detailed instruction ask your engineer or PTO for advice

SETTING OUT ROADS

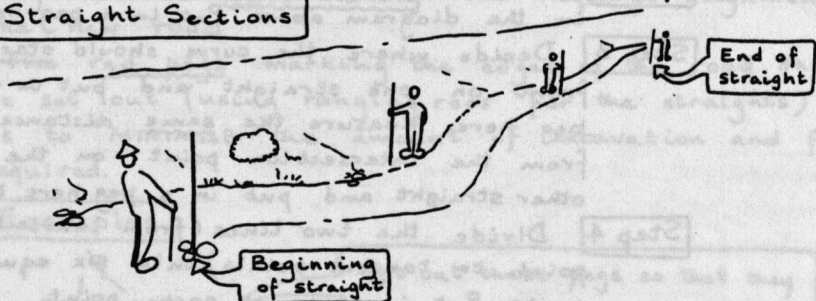
What do you set out? When you are building a road you need to know:

1. What line will the road follow?
2. How much excavation is required?

To set out the line of the road you put in pegs at regular intervals along what will be the middle of the road. This is called the CENTRELINE, written ¢ .

A road should be a combination of straight sections joined by curves. The choice of alignment should minimise the amount of excavation and fill.

Straight Sections



Method

Step 1 Put a ranging rod upright at each end of the section you want to be a straight. These points are now fixed.

Step 2 Get at least two chainmen, each with a ranging rod, to stand in between the two fixed points.

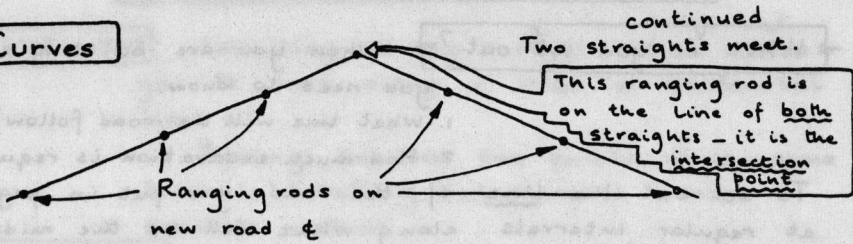
Step 3 Stand behind the ranging rod at the beginning of the straight. Line your eye up with the rod at the other end.

Step 4 Signal to the chainmen to move their ranging rods into line.

Step 5 Put in white pegs along this line of sight every 20 metres. These pegs now mark the centreline (¢) of the new road to be built.

SETTING OUT ROADS

Curves



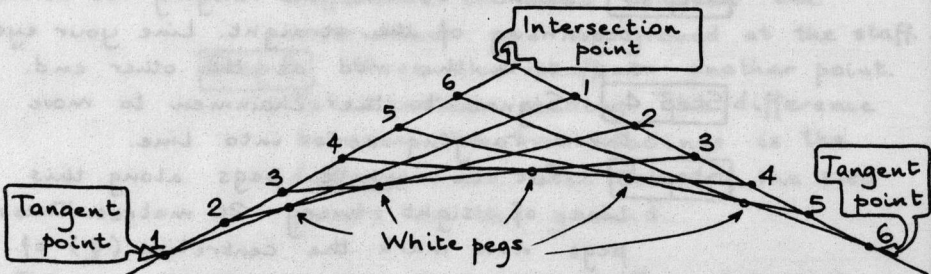
PLAN

Equipment

Pegs, ranging rods, a lot of string

Method

- Step 1** Set out both the straights
- Step 2** Set out the intersection point as shown in the diagram above. Put in a peg here.
- Step 3** Decide where the curve should start from on one straight and put in a peg here. Measure the same distance from the intersection point on the other straight and put in a peg here, too.
- Step 4** Divide the two lines (from intersection point to tangent points) into six equal parts. Put in pegs at each point. Number the pegs as shown below.
- Step 5** Using string join peg 1 to peg 1; peg 2 to peg 2 and so on. Put white pegs in where the strings cross as shown. This is the centreline of the curve.



SETTING OUT ROADS

continued

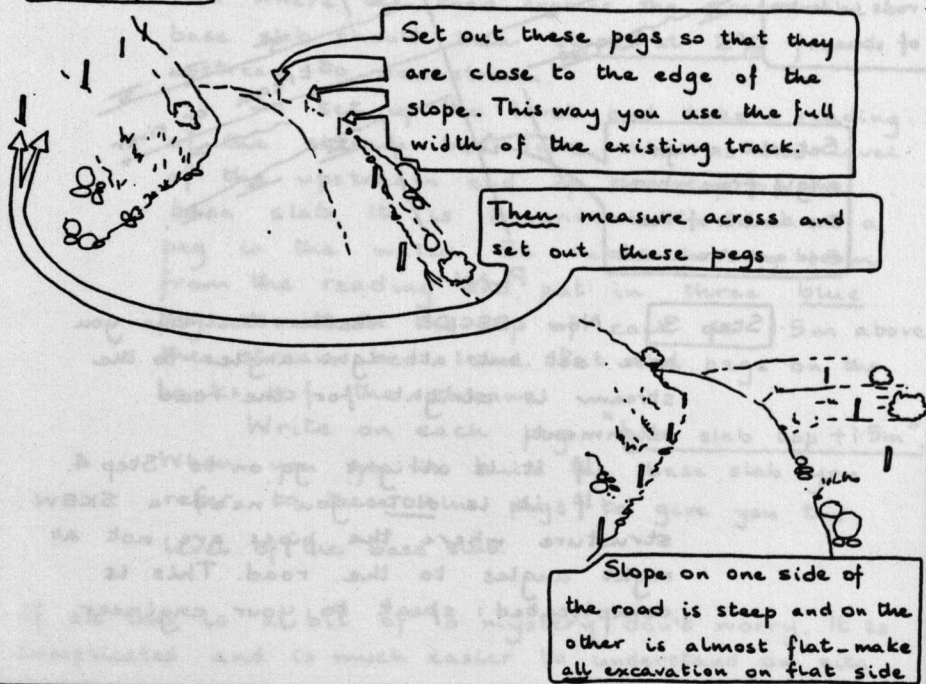
Setting out road width. There are two cases:

1. Where the \mathcal{L} has been set out
2. Where the \mathcal{L} has not been set out.

1. Where the centreline has been set out, measure the width required from the centreline pegs to the edge of the excavation or fill and put in a red peg
2. Where the centreline of the road has not been set out, there is almost always an existing track whose alignment is approximately the required alignment of the new road

The red pegs marking the edges of the road should be set out (using ranging rods for the straights) so as to MINIMISE the amount of excavation and fill required.

Examples



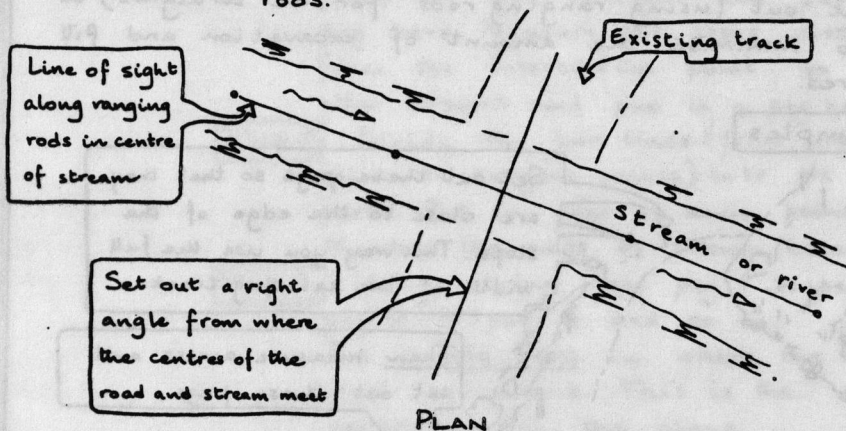
SETTING OUT STRUCTURES

Let's take as an example the setting out of a vented ford.

Equipment Tape hammer pegs (blue, white, and green) ranging rods, level staff and tripod, boning rods.

Method **Step 1** Any cross drainage structure must allow water to pass through it straight and not at an angle. So use ranging rods to set out the line of the stream or river.

Step 2 Set out a right angle from this line of the stream and put in ranging rods.



Step 3 Now DECIDE whether the line you have set out at right angles to the stream is alright for the road alignment.

If it is alright go on to Step 4.

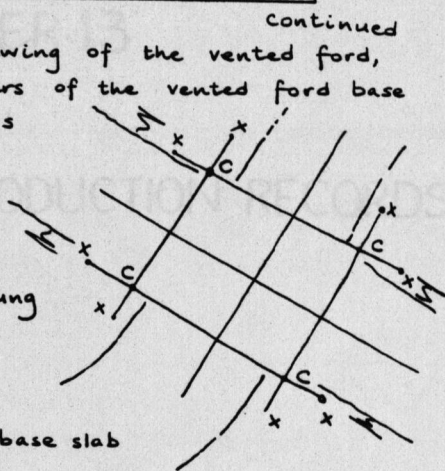
If it is NOT you need a SKEW structure where the pipes are not at right angles to the road. This is complicated: speak to your engineer.

SETTING OUT STRUCTURES

Step 4 Using the drawing of the vented ford, set out the corners of the vented ford base slab with red pegs at points marked C on this drawing and green pegs at points marked X.

(When string is strung from points X to X where they cross is the point C).

The position of the base slab is now fixed.



Step 5 The level of the base slab is now needed. Generally, the level of the top of the base slab should be the level of the stream bed where the road crosses the stream. The base slab should then slope at 2% from upstream to downstream.

So set up the level and take a reading of the stream bed. Take this as the level of the upstream end of the top of the base slab. It is inconvenient to have a peg in the water. So subtract say 1.5m from the reading and put in three blue pegs so that the top of each is 1.5m above the stream bed level. Put the pegs on the banks of the stream.

Write on each peg "base slab top + 1.5m". When you go to build the base slab you refer to these blue pegs to give you the level of the base slab.

If all this is a bit of a mystery, don't worry. It is complicated and is much easier to understand on site

TASKWORK AND PRODUCTION RECORDS

CHAPTER 13

TASKWORK AND PRODUCTION RECORDS

Taskwork and production records are two types of records that are used to measure the performance of workers.

Taskwork records are records that show the time taken to complete a task. They are used to measure the efficiency of workers. Taskwork records are usually used for tasks that are repetitive and can be timed. Examples of taskwork records include time studies, stopwatch time studies, and work sampling.

Production records are records that show the quantity of work produced. They are used to measure the productivity of workers. Production records are usually used for tasks that are not repetitive and cannot be timed. Examples of production records include output records, quality records, and cost records.

Taskwork and production records are both important tools for management. They provide valuable information about the performance of workers and can be used to identify areas for improvement. Taskwork records are used to measure the efficiency of workers, while production records are used to measure the productivity of workers. Both types of records are essential for effective management.

Taskwork records are used to measure the efficiency of workers. They are usually used for tasks that are repetitive and can be timed. Examples of taskwork records include time studies, stopwatch time studies, and work sampling.

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Taskwork and production records are both important tools for management. They provide valuable information about the performance of workers and can be used to identify areas for improvement.

TASKWORK AND PRODUCTION RECORDS

What is Taskwork?

A task is an amount of work given to a man or a gang for one day's pay.

When the work is finished, the man (or gang) can go.

If the work is not finished, the man (or gang) must work until the end of the shift.

Taskwork is the whole business of work done in tasks.

What are Production Records?

For any project, it is vital to know how much it costs and which parts of the work cost how much. The MOST IMPORTANT part of this process is the recording of how many men and how many machines produce how much work.

This information is collected on DAILY PRODUCTION RECORDS

— NOTICE —
DAILY PRODUCTION RECORDS
MUST BE FILLED IN
EVERY DAY, ON THE DAY

Daily Production Records must be filled in by the T.As. in charge of the gangs and must be checked every day by the Tos and STO.

Input is what is needed to do a job like manday (one man for one day) rollerday and so on.

Output is what is produced like m^3 of fill, lin m of culvert, number of erosion checks and so on.

Productivity is Output \div Input

DAILY PRODUCTION RECORDS

A typical Daily Production Record looks like this:

LABOUR CONSTRUCTION UNIT

DAILY AND MONTHLY PRODUCTION RECORD

SITE:

Date:

Officer I/c:

Signature:

Activity	Unit of		Task	F			Prod	F			Prod	F			Prod	Total Input	Total Output	Prod	
	Inp	O/P			Inp	O/P			Inp	O/P			Inp	O/P					
Exc. TOPSOIL	ad	m ³	5.0																
Exc. ORDINARY SOIL	ad	m ³	5.0																
Exc. WEATHERED ROCK	ad	m ³	2.5																
Exc. ROCK	ad	m ³	1.0																
EL COMMON FILL	ad	m ³	5.0																
Haul common fill up to 200m	ad	m ³	5.0																
SC COMMON FILL	ad	m ³	20.0																
PREPARE FORMATION	ad	m ³	15.0																
EL GRAVEL	ad	m ³	2.9																
SC GRAVEL	ad	m ³	9.0																
Collect STONE/ SAND	ad	m ³	2.5																
Load STONE/ SAND	ad	m ³	2.5																
Instal 300/450/ 600mm CULVERT	ad	lm	1.5																
Instal 900mm CULVERT	ad	lm	1.0																
Erosion Checks	ad	no.	20																
Grassing	ad	lm	30																
Instal 900mm v. Ford	ad	lm	5.0																
Load Materials	ad	m ³	-																
Mix and place CONCRETE	ad	m ³	1.0																
Erect CEMENT MASONRY	ad	m ³	1.0																
Erect DRY MASONRY	ad	m ³	2.5																
MAINTENANCE	ad	-	-																
W/men and camp labour	ad	-	-																
Drill for Blasting	ad	no of holes	20-25																
Drill for Blasting	ad	no of holes	75-100																
Haul GRAVEL 0-2km	tpd	m ³																	
Haul GRAVEL 2-7km	tpd	m ³																	
Haul GRAVEL 7-20km	tpd	m ³																	
Haul Materials	tpd	m ³																	
Compact GRAVEL	rd	m ³	250																
Compact COMMON FILL	rd	m ³	250																
Use of Cement	GANG		WHERE USED:	NO. PKTS:					GANG					WHERE USED:		NO. PKTS:		TOTAL CEMENT PKTS:	

AVROLL HUNDAYS:

TOTAL HUNDAYS:

DAILY PRODUCTION RECORDS

Continued

A completed Daily Production Record may look like this:

LABOUR CONSTRUCTION UNIT

DAILY AND MONTHLY PRODUCTION RECORD

SITE: **BASP Roads**Date: **1st April 1984**Officer I/C: **M. P. Lane**Signature: **M. P. Lane**

Activity	Unit of		Task	F	Prod		F	Prod		F	Prod		F	Prod		Total Input	Total Output	Prod
	Imp	O/P			Imp	O/P		Imp	O/P		Imp	O/P		Imp	O/P			
Exc. TOPSOIL	md	m ³	5.0															
Exc. ORDINARY SOIL	md	m ³	5.0	1	26	127.4	49	4	13	65	5.0					39	192.4	49.3
Exc. WEATHERED ROCK	md	m ³	2.5	1	10	31	3.1									10	31	3.1
Exc. ROCK	md	m ³	1.0	1	7	7.2	1.03									7	7.2	1.03
EL COMMON FILL	md	m ³	5.0															
Haul common fill up to 200m	md	m ³	5.0															
SC COMMON FILL	md	m ³	20.0	1	9	165	18.3	4	3	65	21.6					12	230	19.2
PREPARE FORMATION	md	m ³	15.0	2	15	225	15.0									15	225	15.0
EL GRAVEL	md	m ³	2.9	3	74	168	2.27									74	168	2.27
SC GRAVEL	md	m ³	9.0	4	18	168	9.33									18	168	9.33
Collect STONE/SAND	md	m ³	2.5	5	20	50	2.50									20	50	2.50
Load STONE/SAND	md	m ³	2.5	-														
Instal 300/450/600mm CULVERT	md	lm	1.5															
Instal 900mm CULVERT	md	lm	1.0															
Erosion Checks	md	no.	20	4	2	40	20									2	40	20
Grassing	md	lm	30															
Instal 900mm v. Ford	md	lm	5.0															
Load Materials	md	m ³	-															
Mix and place CONCRETE	md	m ³	1.0	5	10	12	1.2									10	12	1.2
Erect CEMENT MASONRY	md	m ³	1.0															
Erect DRY MASONRY	md	m ³	2.5															
MAINTENANCE	md	-	-															
W/men and camp labour	md	-	-	4												4		
Drill for Blasting	md	no of holes	20 - 25															
Drill for Blasting	md	no of holes	75 - 100															
Haul GRAVEL 0-20m	tpd	m ³																
Haul GRAVEL 2-70m	tpd	m ³		3	168	56.0										3	168	56.0
Haul GRAVEL 7-200m	tpd	m ³																
Haul Materials	tpd	m ³																
Compact GRAVEL	rd	m ³	250	1	168	168										1	168	168
Compact COMMON FILL	rd	m ³	250	1	230	230										1	230	230
Use of Cement	GANG	WHERE USED:	V.F. km 6.1	NO. PKTS:	80			GANG	WHERE USED:	NO. PKTS:			TOTAL CEMENT PKTS:	80				

PATROLL HANDAYS: **211**TOTAL HANDAYS: **211**

EARTHWORKS

Here is a TABLE of the Activities which can be involved in Earthworks.

It shows you the name of the activity, the unit of input, the unit of output and the typical task you should set. You can change the task you set ONLY if you discuss this with your PTO/STO or engineer.

Activity	Input Unit	Output Unit	Typical Task	Gang	Input	Output	Prod.
Site Clearance	md	m ²	20-30				
Excavate Topsoil	md	m ³	5.0				
Excavate Ordinary Soil	md	m ³	5.0				
Excavate Weathered Rock	md	m ³	2.5				
Excavate Rock	md	m ³	1.0				
Haul common fill up to 200m	md	m ³	5.0				
Spread and compact common fill	md	m ³	20				
Drill for blasting	md	number of holes	20-25				
Drill for blasting	cd	number of holes	75-100				
Compact common fill	rd	m ³	250				

"Site clearance" includes clearing away rock after it has been blasted

"Excavate rock" is for excavation by hand only. If a compressor is used for drilling for blasting record the men under drill for blasting (md)

Haul common fill up to 200m is by wheelbarrow only. If animal carts are used, a special form will be used

"md" means manday
"cd" means compressorday
"rd" means rollerday

Spread and compact common fill includes the roller operator

Look again at the chapter Earthworks

"Prod." is productivity which is $\frac{\text{Output}}{\text{Input}}$

You fill in these columns. When your gang has been doing a particular activity you write your gang number the input quantity and the output quantity

Compact common fill is for the rollers only: the operators are under spread and compact. Spread and compact also includes watering

EARTHWORKS EXAMPLES

Example Suppose you are TA in charge of F3. Gang F3 has 42 men at work today. Your STO has told you to strip topsoil and has shown you where. The formation width is 9.2m.

← What do you do ?? →

Step 1 You ought to know how deep the topsoil is. If you have not already found out, quickly dig a few holes to find out the depth of topsoil. (See chapter on earthworks)

Suppose the depth is 0.2m, on average.

Step 2 The width is 9.2m

The average depth is 0.2m

The TASK per man is $\underline{5.0 \text{ m}^3/\text{md}}$

So the LENGTH per man is $\underline{5.0}$

$$9.2 \times 0.2$$

$$= \underline{2.72\text{m}} \text{ (to 2 places of decimals)}$$

Step 3 Mark out lengths of 2.72m along the road and show each man his task.

Step 4 As each man finishes, check he has excavated all his topsoil and removed it from the formation width.

Step 5 Stay at the site until all the men have finished their work and all the tools have been checked and collected.

Step 6 Go to the camp and fill in the DAILY PRODUCTION RECORD.

The input is 42 md

The output is $42 \times 9.2 \times 0.2 \times 2.72 = 210 \text{ m}^3$

Activity	Input Unit	Output Unit	Typical Task	Gang	Input	Output	Prod.
Excavate Topsoil	md	m ³	5.0	F3	42	210	5.0

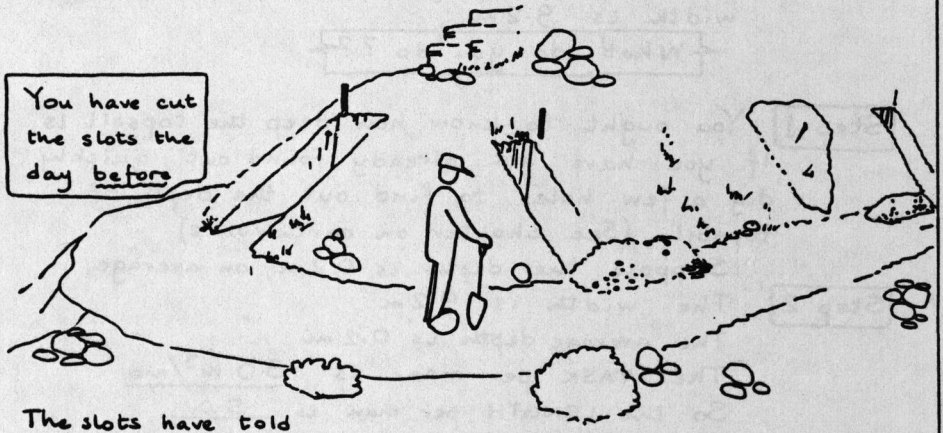
EARTHWORKS EXAMPLES

continued

Another Example

Suppose you are the TA in charge of gang F6. Out of the 62 men on the books, 53 have reported for work. You have been told to do formation.

You have cut the slots the day before



The slots have told you the type of ground. Let's say it is ordinary soil but there is a large rock, average height 2.0 m average width 1.5 m average length 1.0 m, which is on the route. Now take each section where the slots are the same size separately. If the terrain varies a lot you may have to do a separate calculation for each length between slots.

For this example take the first length. Say the slot height is 1.7 m and width (at right angles to the road) is 1.4 m. The length of road which these measurements apply to is 25 metres. The slot height at the road edge is zero—the slot side is a TRIANGLE.

Step 1 Calculate the task per man for the first section.

In ordinary soil task is $5.0 \text{ m}^3/\text{md}$.
 Area of slot side = $\frac{1}{2} \times 1.7 \times 1.4 = 1.19 \text{ m}^2$
 So length per man = $\frac{5.0}{1.19} = 4.2 \text{ m}$

The length of this section is 25 m. You need $25 \div 4.2 = 6$ (to the nearest whole number) men on this section

EARTHWORKS EXAMPLES

continued

There are 6 men excavating ordinary soil, total volume $\frac{1}{2} \times 1.7 \times 1.4 \times 25 = 29.75 \text{ m}^3$

Step 2 You now need men to spread and compact this "common fill". How many? Well, the typical task for spread and compact common fill is $20 \text{ m}^3/\text{md}$. You need $29.75 \div 20 = 1.5$ approximately. You can either put 2 men on this or calculate the spread and compact over a longer length of road, to get a better productivity.

Step 3 Set the task to excavate the rock.

Volume = $1.5 \times 1.0 \times 2.0 \text{ m}^3 = \underline{3.0 \text{ m}^3}$

Task = $1.0 \text{ m}^3/\text{md}$

So you need $3.0 \div 1.0 = 3$ men to do the task.

Step 4 Now go on with setting tasks for the remaining men. Remember for every 4 men on excavate ordinary soil you need 1 man to spread and compact.

Remember Senior labourers must be included in the mandays for the activity they are working on.

Step 5 Stay at site until all the men have finished their work and all the tools have been checked and collected.

Step 6 Go to the camp and fill in the DAILY PRODUCTION RECORD

Activity	Input Unit	Output Unit	Typical Task	Gang	Input	Output	Prod.
Excavate Ordinary Soil	md	m^3	5.0	F6	40	210	5.25
Excavate Weathered Rock	md	m^3	2.5	-	-	-	-
Excavate Rock	md	m^3	1.0	F6	3	3.0	1.0
Spread and compact common fill	md	m^3	20	F6	10	210	21.0
Compact common fill	rd	m^3	250	F6	1	210	210

SIDE DRAINAGE

Ditches The ditches will almost always be one of the shapes given in the Standard Drawing of Ditches.

Step 1 When you know which ditch shape you must use, CALCULATE the cross sectional AREA

Step 2 Each day, look at the ground to be excavated on the next day, and decide:

is it ORDINARY SOIL
or WEATHERED ROCK
or ROCK ?

Step 3 Using the correct volume task for the type of ground, calculate the LENGTH per man.

$$\text{Length per man} = \frac{\text{TASK (m}^3/\text{md)}}{\text{Cross Sectional Area (m}^2\text{)}}, \text{ in m}$$

Step 4 Mark the length per man on the ground. Next day, when the task is to be done, show each labourer his task.

Step 5 Explain the ditch is excavated in two stages. (look at chapter on Drainage)

Step 6 Stay at the site until you have checked each man's work (with a template if you have one) and until all the tools are checked and collected.

Step 7 Go to the camp and fill in the DAILY PRODUCTION RECORD

Activity	Input Unit	Output Unit	Typical Task	Gang	Input	Output	Prod.
Excavate ordinary soil	md	m ³	5.0				
Excavate weathered rock	md	m ³	2.5				
Excavate rock	md	m ³	1.0				
Spread and compact common fill	md	m ³	20				
Compact common fill	rd	m ³	250				

You fill in here

SIDE DRAINAGE

Erosion Control

continued

Erosion checks: Taskwork for erosion checks is easy—it is a number of checks to be built in a day. The task per man is 20 no./md. Try to choose a labourer who understands the work:

Production Record:

Gang Input Output Prod.

Erosion checks	md	no.	20				
----------------	----	-----	----	--	--	--	--

You fill in here

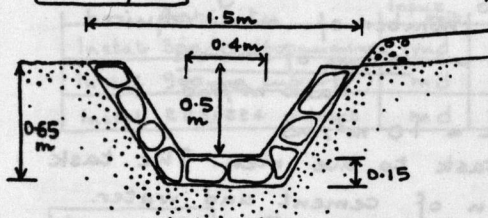
Grassing: Task is set as linear metres of ditch grassed.

Grassing	md	lin m	30				
----------	----	-------	----	--	--	--	--

Stone pitching: Taskwork is calculated in the same way as for CEMENT MASONRY and measured in volume.

Example

Lined ditch for urban roads.



Approximate area of cross section of masonry

$$= (0.65 \times 0.15) \times 2 + 0.15 \times 0.4$$

$$= 0.255 \text{ m}^2$$

Task for cement masonry = $1.0 \text{ m}^3/\text{md}$
 So length per man = $\frac{1.0}{0.255} = 3.92 \text{ lin m/man}$

For simplicity give each man 4.0 m (say for 9 men)

So DAILY PRODUCTION RECORD

Collect stone/sand	md	m ³	2.5	F7	4	10.0	2.5
Erect cement masonry	md	m ³	1.0	F7	9	9.18	1.02

CROSS DRAINAGE

Drifts

The activities and taskwork are in three parts: excavation for drift
collecting aggregate for concrete
placing concrete.

Excavation is done exactly the same way as excavation to formation: decide on the type of ground, measure the volume to be excavated, calculate the number of men required, explain the task and so on.

Collection of aggregate is straightforward. Calculate the volume required (= the volume of the concrete) and collect in wheelbarrows. If a tipper is needed speak to your STO.

Concrete

Step 1 Calculate the volume of concrete required. It will be length x width x height.

Step 2 Calculate the number of men required.
Number of men = $\frac{\text{Volume of concrete}}{\text{task m}^3/\text{md}}$

Task for concrete = 1.0 m³/md.

Step 3 Explain the task to the men. The task includes collection of cement and water.

Step 4 Check work is finished well

Example

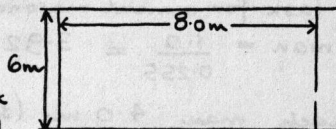
Excavation
in weathered rock

Task = 2.5 m³/md

No: men = $\frac{7.2}{2.5} = 3$

2.5 (to the nearest whole no.)

So use 7 men



PLAN

Volume of concrete = $8 \times 6 \times 0.15$
= 7.2 m³

number of men = $\frac{7.2}{1.0} = 7.2$
1.0

Fill in these parts of the Daily Production Record

Activity	Input Unit	Output Unit	Typical Task		Input	Output	Prod.
Excavate weathered rock	md	m ³	2.5	F16	3	7.2	2.4
Collect stone/sand	md	m ³	2.5	F16	3	7.5	2.5
Mix and place concrete	md	m ³	1.0	F16	7	7.2	1.03
Use of cement	GANG: F16 Where used: Drift km: 1.7 No: pnts: 51						

CROSS DRAINAGE

continued

Culverts

First, look at the chapter on drainage.

Step 1 You ought to know how long the culvert is supposed to be. It will almost always be less than 8 metres.

You know what diameter it should be.

So for:

300 450 or 600 mm diameter use 5 men

900 mm diameter use 6 men

EE3 or EE4 Armco culverts use 7 men.

Step 2 Explain the task which is a GANG TASK to the gang.

Step 3 When the whole task is finished the gang can go, when the tools have been checked and collected.

Step 4 Go to the camp and fill in the DAILY PRODUCTION RECORD

Activity	Input unit	Output unit	Typical rate	Gang	Input	Output	Prod.
Instal 300/450/600mm culvert	md	linm	1.5				
Instal 900mm culvert	md	linm	1.0				
Instal EE3/EE4 culvert	md	linm	0.87				

You fill in here

Headwalls

Taskwork is calculated the same way as for CEMENT MASONRY.

Calculate the volume of masonry in one headwall from the standard drawing.

Task for cement masonry = $1.0 \text{ m}^3/\text{md}$

So decide on the number of men required.

Complete the DAILY PRODUCTION RECORD for

- Erect cement masonry
- Collect stone/sand
- Use of cement pkts.

VENTED FORDS

First of all look at the section on vented fords in the chapter on Drainage. This tells how to build a vented ford.

Once you understand how to build a vented ford, the taskwork is not too hard.

Take each part of the work separately and decide which ACTIVITIES will be used in each part.

PART OF THE WORK

ACTIVITIES

- 1 Make a diversion:

Excavate ordinary soil
or Excavate weathered rock
Spread and compact common fill
Compact common fill

- 2 Excavate for base slab
and cut off walls

Excavate ordinary soil
or Excavate weathered rock

- 3 Build cut off walls

Erect cement masonry
Collect stone/sand.

- 4 Place concrete in base
slab

Mix and place concrete
Collect stone/sand

- 5 Instal the pipes

Instal 900mm v.ford pipes

- 6 Build masonry around the
pipes

Erect cement masonry
Collect stone/sand

- 7 Excavate for foundations
of wingwalls and build the
wingwalls

Excavate ordinary soil
Excavate weathered rock
Erect cement masonry
Collect stone/sand.

- 8 Place concrete around
the pipes

Mix and place concrete
Collect stone/sand

- 9 Place weldmesh and
concrete for deckslab

Mix and place concrete
Collect stone/sand

- 10 Build downstream apron

Erect cement masonry
Mix and place concrete
Collect stone/sand.

VENTED FORDS

continued

- 11 Bring fill to make up the road embankment.

Excavate ordinary soil
Excavate weathered rock
Haul common fill up to 200m
Spread and compact common fill
Compact common fill.

This part of the work needs PLANNING.

You need the right number of men excavating to keep the men hauling busy and enough men spreading and compacting to handle all the fill.

How do you do all that??

Task for excavate ordinary soil is $5.0 \text{ m}^3/\text{md}$.

Task for haul common fill up to 200m is $5.0 \text{ m}^3/\text{md}$

Task for spread and compact common fill is $20.0 \text{ m}^3/\text{md}$.

(Task for compact common fill is $250 \text{ m}^3/\text{rd}$)

The easiest way to do this is put one man on the activity with the highest productivity in this case spread and compact common fill.

Now see how many men are needed on the other activities.

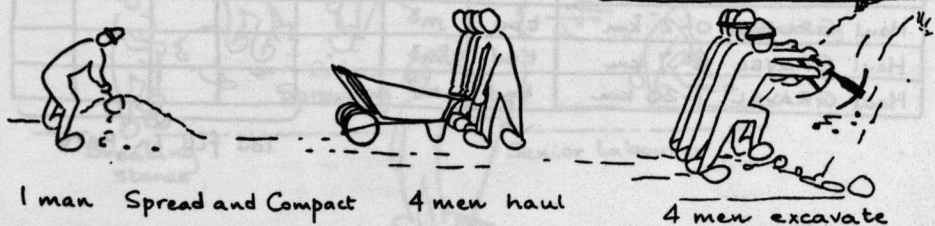
To produce 20 m^3 of ordinary soil you need

4 men excavating and loading and

4 men hauling.

So you need $4 + 4 + 1 = 9$ men for every 20 m^3 of fill.

If the soil is weathered rock task is halved



GRAVELLING

As before if you take each part of the work separately you will be able to set the correct tasks.

Quarries Use a gang task based on the TABLE

Journey time →	UP TO 15 MINS	15-20 MINS	20-25 MINS	25-30 MINS	30-35 MINS	35-40 MINS	40-45 MINS
Number of men ↓	TASK: Number of loads (Gr ³ tipper)						
25	15	14	12	10	*	*	*
24	15	14	12	10	9	*	*
23	14	13	11	9	8	8	*
22	13	12	11	9	8	7	6
21	13	12	10	9	8	7	6
20	12	11	10	8	7	6	6
19	11	11	9	8	7	6	5
18	11	10	9	8	7	6	5
17	10	9	8	7	6	5	5

* These journey times are too long to allow so many men in the pit.

Journey time does not include loading.

Excavate and load gravel task 2.9 m³/manday

When reporting VOLUME of gravel ALWAYS use the compacted volume

Compacted volume = no. of loads x volume of each tipper x 0.8.

In this way the same volume is reported from the quarries and the spreading.

Reporting from the quarries will involve the following activities

Activity	Input Unit	Output Unit	Typical Task	Gang	Input	Output	Prod.
Exc. and load GRAVEL	md	m ³	2.9				
Haul GRAVEL 0-2 km	tpd	m ³					
Haul GRAVEL 2-7 km	tpd	m ³					
Haul GRAVEL 7-20 km	tpd	m ³					

You fill in here

GRAVELLING

continued

Spreading, Watering, Compacting

All this comes under one ACTIVITY.

The task you set will vary according to the quantity of gravel being brought to the site. The more gravel that is delivered, the higher the productivity you can achieve. This is because the watering, stone breaking and compaction have to be done by separate labourers. If there is not much gravel being delivered these men are not fully occupied. The gang should consist of:

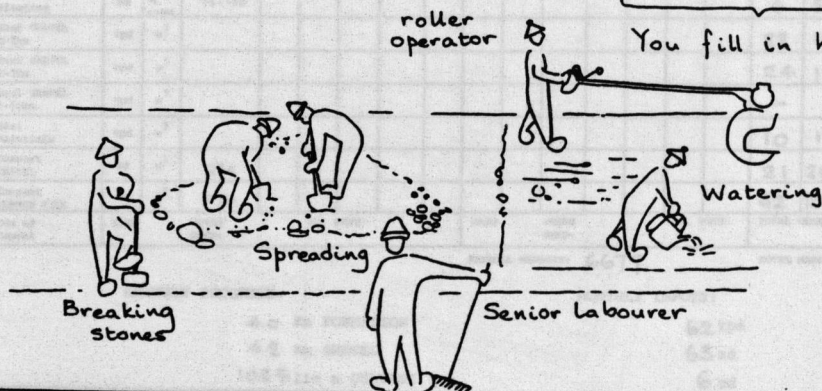
Water collection and spreading	2-4 men
Breaking stones	1-2 men
Roller operator	1-2 men
Senior labourer	1-2 men
Spreading gravel	varies.

As a general rule you should try to achieve a task (productivity) of 9.0 m³/md of compacted gravel.

Activity	Input Unit	Output Unit	Typical Task	Gang	Input	Output	Prod
Spread and compact GRAVEL	md	m ³	9.0				
Compact GRAVEL	rd	m ³	250				

roller operator

You fill in here



MONTHLY PRODUCTION RECORDS

These are filled in by the officer in charge of a site.

The SAME FORM is used for monthly production as for daily production.

The whole month's daily production records are laid out so that all the TOTALS are visible and the totals of these for each activity are put on a monthly sheet.

The monthly progress and plant totals are also filled in.

The total mandays are filled in and the payroll mandays taken from the pay sheets are filled in.

For each day and for each month, the PAYROLL MANDAYS must equal TOTAL MANDAYS from the production records.

On the next page is a typical MONTHLY PRODUCTION RECORD, filled in. Study it carefully and ask your STO or PTO if you have any questions.

Continued

MONTHLY PRODUCTION RECORDS

LABOUR CONSTRUCTION UNIT

Date: October 1984

Officer i/c:

A Sello

Signature:

DAILY AND MONTHLY PRODUCTION RECORD

SITE: SEAKA NOWANA Phase I

SITE: SEKA NUNANA Phase 1																							
Activity	Unit of		Task	F	Inp		O/P	Prod	F	Inp		O/P	Prod	F	Inp		O/P	Prod	F	Total Input	Total Output	Prod	
	Imp	O/P			Imp	O/P				Imp	O/P												
Exc. TOPSOIL	md	m ³	5.0																		253	1205	4.76
Exc. ORDINARY SOIL	md	m ³	5.0																		1262	6257	4.96
Exc. WEATHERED ROCK	md	m ³	2.5																		1289	3108	2.41
Exc. ROCK	md	m ³	1.0																		998	987	0.99
EL COMMON FILL	md	m ³	5.0																		92	450	4.89
Haul common fill up to 200m	md	m ³	5.0																		93	450	4.84
SC COMMON FILL	md	m ³	20.0																		569	10802	19.0
PREPARE FORMATION	md	lm	15.0																		262	4200	16.0
EL GRAVEL	md	m ³	2.9																		950	2660	2.8
SC GRAVEL	md	m ³	9.0																		280	2660	9.5
Collect STONE/SAND	md	m ³	2.5																		103	254	2.47
Load STONE/SAND	md	m ³	2.5																		40	110	2.75
Instal 300/450/600mm CULVERT	md	lm	1.5																		101	97.6	0.97
Instal 900mm CULVERT	md	lm	1.0																		6	4.88	0.81
Erosion Checks	md	no.	20																		24	480	20
Grassing	md	lm	30																		-	-	-
Instal 900mm v. Ford	md	lm	5.0																		5	24.4	4.88
Load Materials	md	m ³	-																		100	180	/
Mix and place CONCRETE	md	m ³	1.0																		104	93	0.89
Erect CEMENT MASONRY	md	m ³	1.0																		111	132	1.19
Erect DRY MASONRY	md	m ³	2.5																		10	27	2.70
MAINTENANCE	md	-	-																		-	430	-
W/man and camp labour	md	-	-																		-	160	-
Drill for Blasting	md	no of holes	20 - 25																		25	505	20.2
Drill for Blasting	md	no of holes	75 - 100																		6	505	84.2
Haul GRAVEL 0-2km	tpd	m ³																			28	1600	57.1
Haul GRAVEL 2-7km	tpd	m ³																			24	1060	44.2
Haul GRAVEL 7-20km	tpd	m ³																			-	-	-
Haul Materials	tpd	m ³																			10	180	18.0
Compact GRAVEL	rd	m ³	250																		21	2660	127
Compact COMMON FILL	rd	m ³	250																		42	10102	257
Use of Cement	GANG		WHERE USED:		NO. PKTS:		GANG		WHERE USED:		NO. PKTS:		TOTAL CEMENT PKTS:		63								

PAYROLL HOURS: 6677

TOTAL HOURS: 6677

MONTHLY PROGRESS:

4.0 Km FORMATION

4.2 Km GRAVEL

102.5 lin m CULVERT

MONTHLY INPUTS:

62 tpd

63 rd

6 cd

DIRECT COST FORMS

continued.

This is a form for
staff and labour.

Fill it in daily.

[illegible]

CHAPTER 14

SETTING UP A SITE

SETTING UP A SITE

What does that involve?

Setting up a new site and then running the whole show is a complicated business. It requires experience and training. It is always the responsibility of a TO, STO or PTO. This chapter is here to give you some idea of what is involved—it cannot teach how to do it.

How does a new job start?

Usually, as a first step, a project is identified as being necessary. An engineer then surveys the project, makes a design and an estimate of cost based on a Bill of Quantities.

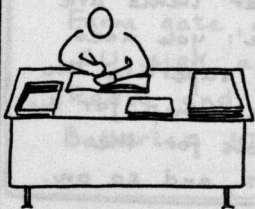
This lot is put together to make a JOB REPORT.

Next enough money is found for the project either from the Government or a donor agency.

When the money is received at the Ministry of Works, that is the signal for ACTION in the L.C.U.

Requisitions are made for:

- 1 Tools and equipment required.
- 2 Plant required, with dates
- 3 Stores required for site camp
- 4 Staff requirements with dates
- 5 Labour recruitment, with dates
- 6 Construction materials
- 7 Administration forms and stationery

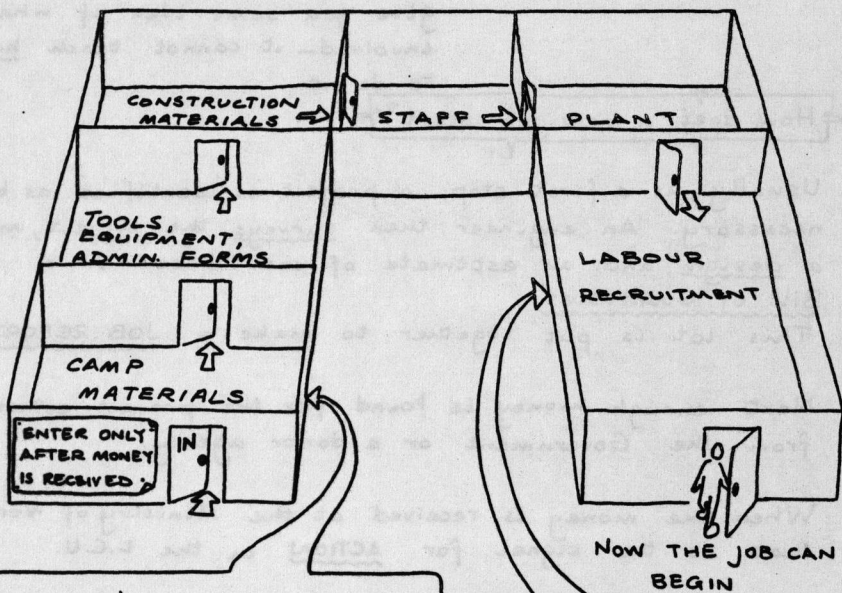


SETTING UP A SITE

continued.

It may seem obvious, but it is easily forgotten that recruitment cannot take place until the camp tools equipment and plant are on site, and until the staff are available.

To get an idea of the sequence of events, follow the route around the "setting up house" shown here



You must receive camp materials (huts, etc) before the tools and equipment can be received on site

This is a sequence of events. Of course some things take time to organise so they have to be arranged sometime before they take place

Labour recruitment can only start when all the other items are complete: you need staff to supervise the labour, a camp for the staff, tools for the labourers, and so on.

CAMP

The site camp is where the permanent labourers and the site staff all have to live. They spend far more of their time living in the camp than they do at home.

So it is IMPORTANT to make the camp a good place to live.

Each camp is different but these are some of the basic requirements.

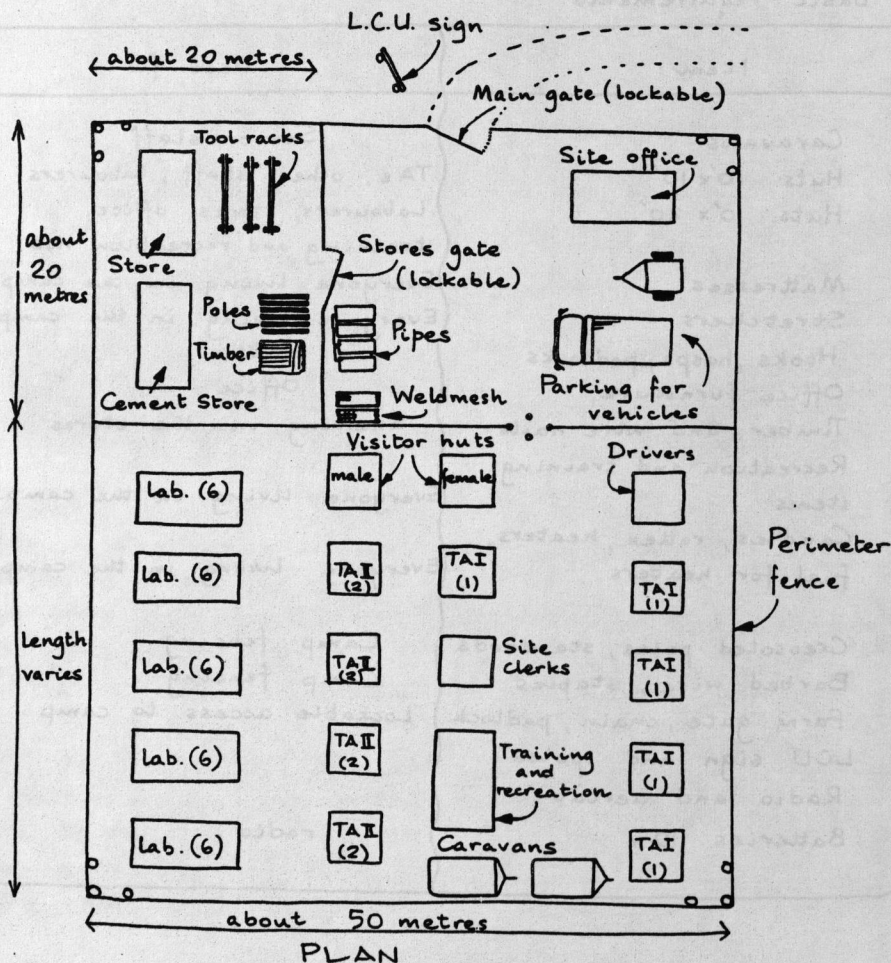
Item:	Used for:
Caravans	Senior staff
Huts 10'x10'	TAs, other staff, labourers
Huts 10'x20'	Labourers, stores, office, training and recreation hut.
Mattresses	Everyone living in the camp
Stretchers	Everyone living in the camp.
Hooks, hasps, padlocks	Huts
Office furniture	Office
Timber and wire nails	Shelving in the stores
Recreation and training items	Everyone living in the camp.
Candles, rattex, heaters,	Everyone living in the camp
fuel for heaters	
Creosoted poles, standards	Camp fencing
Barbed wire, staples	Camp fencing
Farm gate, chain, padlock	Lockable access to camp
LCU sign and poles	
Radio and aerial	
Batteries 12v	radio

CAMP LAYOUT

Care should be taken to build a camp which is efficient, secure and pleasant to live in.

Always make sure water is available nearby and always make sure the village chief is happy with your plans.

A typical layout would look like this:



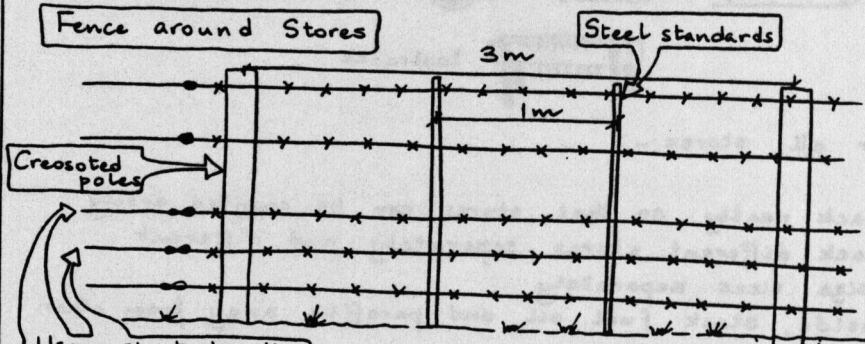
CAMP FENCE

The camp fence is an important part of security.
Erect the fence carefully and well.

Equipment

Barbed wire (comes in 50 kg rolls)
Creosoted poles (125 mm diameter, 2m long)
Steel standards
Fence strainer

Fence around Stores

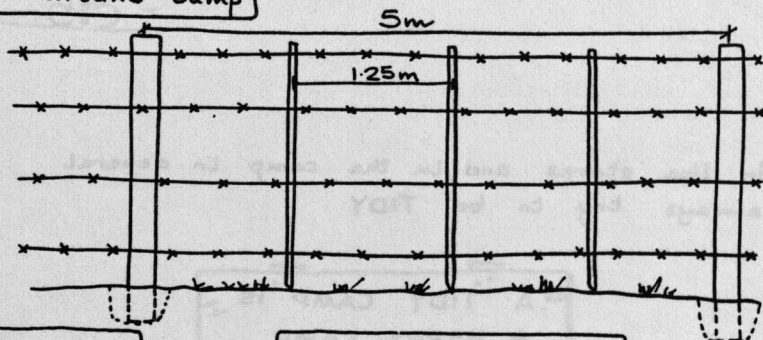


Use a short length of plain (baling) wire tied to the barbed wire to use the fence strainer

Use 5 strands of wire around the stores

Creosoted poles should be put into the ground 0.4m and packed with concrete

Fence around camp

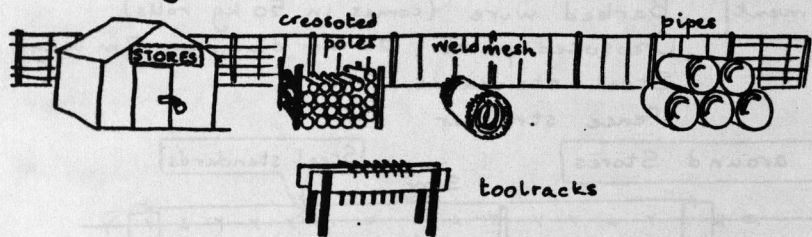


Creosoted poles at 5m apart

Use 4 strands of wire around the camp

CAMP STORES

Picks, shovels, wheelbarrows and large stores have to be stored outside the stores hut, so the fence is very important.



For all stores:-

1. Stack neatly so that stores can be counted easily
2. Stack different stores separately and different size sizes separately
3. Inside, stack fuel oil and paraffin away from other stores.
4. Stack cement in a separate hut. (See chapter on Concrete Technology)
5. Have a watchman on duty at all times



In the stores and in the camp in general always try to be TIDY



STANDARD DRAWINGS

