Footpaths and Tracks

A Field Manual for their Construction and Improvement

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Consultants in Transport for Rural Development

TABLE OF CONTENTS

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GLOSSARY

Alignment	The route that a path will follow
Camber	A cross slope on the path surface that causes water to run off from the centre to the edges
Crossfall	A slope across the whole width of a path
Cross Drainage	The transfer of water from one side of a path to the other
Culvert	A cross drainage structure which takes water under the path
Gradient	The steepness of the slope measured as the rise per unit length e.g. a 1 in 10 gradient (10%) is a rise of 1m over a length of 10m
Grubbing	Removal of grass roots and bush stumps
Gulley	A narrow piece of ground that has steep upward slopes on each side
Hairpin Bend	A very sharp bend on a path on a steep slope. The bend almost turns the path back on itself
Imported Material	Material e.g. earth, sand or gravel which is carried to the path from another area to improve the surface of the path
IMT	Intermediate Mode of Transport e.g.. Bicycles or animal carts
Passing Place	A widening of a short section of a narrow path to allow traffic from opposite directions to overtake
Path	Any cleared route which is used by pedestrians, animals, bicycles or other IMTs
Scour	The erosion of material around a structure or in a drain due to water flow
Setting Out	The process of marking out the route of the path
Spot Improvements	Improvements which are made to short sections of the path to overcome local problems and therefore improve the overall quality
Stone Pitching	A layer of stones which are laid on the ground to prevent erosion from flowing water
Task Rate	the amount of work that will typically be completed by one person during one working day
Zig-Zag Footpaths	Footpaths which run up or down a hill with frequent hairpin bends

1. INTRODUCTION

1.1 BACKGROUND TO THE MANUAL

The most common means of travel in the rural areas of developing countries is walking. Distances walked are sometimes long and often involve load carrying on the head or shoulders. Many, if not most, villages of rural Africa and Asia do not have road access. Nor is it realistic to assume that roads will be built to all these villages in the foreseeable future. Most of these villages are, and will remain, dependant on the existing extensive network of paths and tracks for access to agricultural fields, sources of water and firewood and to the outside world.

Rural paths and tracks have rarely been "constructed" but have evolved over a period of time through the passage of people, bicycles, carts and animals. Generally this evolution has resulted in a good alignment which balances the shortest distance with the least effort in terms of avoiding obstacles and minimising hill climbing. Problems with natural paths and tracks do however arise, making them difficult and sometimes dangerous for travellers, and therefore inhibiting the movement of people and goods. Simple improvements to paths and tracks can often bring about substantial benefits to rural communities by making the paths safer and easier to use. Spot improvements on short sections of the path or tracks are usually the most effective. These are targeted at improving specific problems, of which the most common are:

- Marshy and water logged areas caused by poor drainage
- Slipperiness and erosion caused by steep gradients
- Wet and marshy ground
- Dangerous steep and rocky sections and
- Difficult stream or river crossings

In many cases these problems can be remedied by using simple techniques some of which are described in this manual.

Sometimes measures have been taken by the local people themselves to improve these sections but often their resources are limited or they do not have the technical knowledge or skills to overcome the problems successfully.

Some recent internationally supported projects have assisted rural communities to improve and upgrade their paths. Examples include the Makete Integrated Rural Transport Project in Tanzania the IRTP in Malawi and the Kosi Hill Area Rural Development Programme in Nepal. These projects successfully implemented improvements to rural paths and tracks, but highlighted the lack of practical advice on the appropriate techniques for improving paths and tracks. A number of these projects have produced their own manuals to guide field workers. This manual draws on this experience to provide a more generally available source for guidance on improving paths and tracks.

The manual presents practical measures that can be taken to improve or upgrade paths and tracks in developing countries. These improvements are not only directed to making travel by foot easier but also cover the need to provide access for intermediate means of transport (IMT) such as pack animals, bicycles, wheelbarrows and carts. The manual includes guidelines on organisational issues; the appropriate standards for paths and tracks for different uses; as well as specific technical solutions to problems which are commonly encountered on sections of paths and tracks.

1.2 THE ORGANISATIONAL ENVIRONMENT

The ownership of footpaths and tracks is rarely clearly defined. Usually they are considered the responsibility of the communities that use them. Financial resources are seldom available to maintain this vital level of infrastructure.

Local communities who wish to improve these paths and tracks will often be required to provide their own resources which will usually be in the form of free labour. The coordination of improvement or maintenance of paths and tracks will usually be undertaken by a formal or informal community organisation or group. These groups can take a number of different forms;

Legal / Administrative organisations

These organisations can either be the lowest level of local government administration operating at a village level or be part of the traditional leadership structure

Social and economic organisations

These groups are defined by the members themselves and reflect the prevailing social and economic characteristics in the rural population. Examples of these groups may be traders, farmers, church members and co-operatives.

Geographical communities

Groups defined in geographical terms for example caused by natural features or catchment areas, working with a communal interest.

The manual gives guidelines on providing technical assistance to these groups. However, it does not cover assistance in mobilising the community which is considered a specialised input which requires reference to more specific guidelines.

1.3 SUPPORTING LOCAL ORGANISATIONS

The community organisations formed to construct a footpath will usually need technical support in order to improve a footpath and particularly to overcome specific problems along the path. The technical support required will depend on the difficulty of the local terrain.

This manual aims to provide the technical background that is required to provide the support to the community group. This support may be provided, for instance by a technician from the local government or by a field worker from a NGO.

The manual provides the technical background required through the use of simple diagrams and text to enable a technician to provide the necessary support to the community group. It is envisaged that the person providing technical support will make use of the diagrams in the manual when explaining issues and tasks to be undertaken by the community group.

1.4 HOW TO USE THIS MANUAL

The manual is divided into 5 sections each covering a different aspect of the construction /improvement of footpaths and tracks. 5 Annexes contain additional detailed information to supplement that given in the main sections.

Chapter 2: Planning and Organisation

This is divided into two sub-sections. The first deals with the *Institutional* aspects of working with communities to identify, agree and organise the work to be done.
The second sub-section deals with the *Technical* aspects of identifying problems and planning the improvements to be carried out. It covers setting design standards, identifying the work to be done and estimating the resources needed.

Chapter 3: Technical Guidelines on Design and Construction

This section provides the central source of technical information on the design of footpaths and on the methods for dealing with the main problems found along footpaths. There are subsections on:

- Alignment and setting out
- Improving the path surface
- Drainage
- Paths on steep slopes
- Crossing marshy ground
- Simple water crossing such as stepping stones, drifts and culverts

Chapter 4: Footbridges

Providing durable footbridges is one of the major problems for footpaths and tracks. This section provides guidelines for planning of footbridges and the selection of an appropriate design. Details of simple designs for short spans which are considered within the capability of community construction are presented. References are given for guidelines on longer, more complex footbridges, such as suspension bridges.

Chapter 5: Maintenance

Regular maintenance of footpaths is essential to sustain the work put into improving the paths and the improvements achieved. This section provides guidelines on maintenance to be carried out and how this might be organised.

Annex 1: Stone Paths

Stone paths/tracks are particularly suited to areas where the surface is poor or erosion is a problem. This annex presents detailed guidelines on construction of stone footpaths. It is prepared by a consultant who specialises in this type of work, particularly in hilly/mountainous areas.

Annex 2 *Sample Documents for Agreements with the Community*

This annex contains examples of documents which may be used to draw up agreements between communities and the technical assistance team.

Annex 3: *Examples of Footpath Features and Problems of Inadequate Maintenance*

This annex contains illustrations of footpath features from Makete in Tanzania and some of the problems that have arisen from inadequate maintenance.

Annex 4: *Case Studies*

This annex contains case studies from field testing of the manual carried out in Malawi and Sri Lanka.

Annex 5: *References and Support Organisations*

This annex provides information on reference sources, both general and specialised, on footpaths and tracks and on organisations that may be able to provide advice and assistance.

2. ORGANISATION AND PLANNING

The first stage in improving or constructing a footpath is the planning stage. This stage identifies what needs to be done, how it is to be done and what resources will be needed. Proper planning is essential to make sure that the work proposed will effectively achieve the improvements needed and that it is carried out smoothly and efficiently.

The 5 finger exercise set out in Figure 2.1 can help to make sure that all the relevant factors involved in planning and organising the work are properly considered.

Much of the planning stage will involve technical issues. This will include:

- Identifying the main functions and users of the footpath
- Selecting appropriate design standards for the footpath
- Identifying the improvements or new construction needed
- Choosing the most appropriate options for improving the footpath and preparing specifications and instructions to carry out this work
- Estimating the resources needed, including tools, materials and labour
- Organising the work to be carried out
- Monitoring the work that is being carried out
- Planning and specifying the ongoing maintenance that will be needed to keep the path in good condition

However, working in harmony with the community is equally vital. In most cases the need to improve footpaths and the request for technical assistance will come from the communities that use the paths. The community will therefore generally be the client and will provide most of the resources, particularly labour. It is very important that this is clearly recognised and acknowledged in providing the technical assistance. The community must be fully consulted at all stages of the planning and organisation of the work to be carried out. The community will normally be responsible for managing the implementation of the work.

Written agreements should be prepared which clearly state the responsibilities and inputs of both the community and technical assistance and specify the work to be carried out.

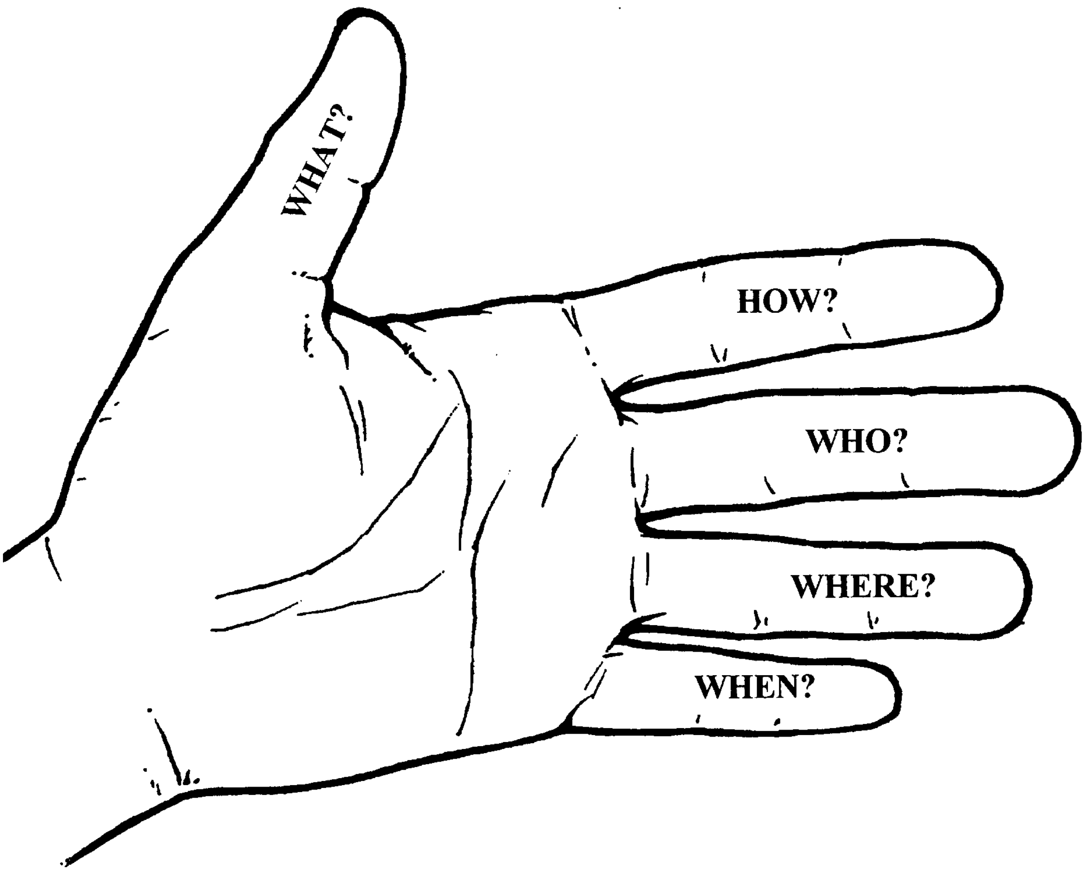
This chapter provides guidelines on both aspects of planning and organising the work:

- Section 2.1 provides guidelines on working with the community to plan, organise and implement the work. It does not cover mobilising and organising the community which is considered an issue outside the scope of this manual
- Section 2.2 deals with the technical issues of planning and organising the work

Although the issues are treated separately for clarity, they are very much intertwined as indicated in the step by step guide shown in Box 2.1

Figure 2.1: The 5 Finger Planning Exercise

To help carry out the planning exercise at each step ask the **5 Finger Questions:**



WHAT	is the task that you are planning? Why is it needed?
HOW	is the work going to be carried out? What resources are needed?
WHO	is going to carry out this work? Will they need training?
WHERE	is the work to be done?
WHEN	is the work going to be done? How long will the work take?

BOX 2.1: STEPS IN PLANNING AND ORGANISATION OF WORK

TECHNICAL WORK | **LIAISON WITH COMMUNITY**

Initial Meeting (Liaison with Community)
- community outlines problems and assistance needed
- discuss stages of planning

Carry Out Survey of Path(s) (Technical Work)
- identify key features of path and surrounds
- assess nature of traffic using path; carry out traffic survey if needed
- identify access problems along path
- identify and assess options for improvements

Obtain Feedback (Liaison with Community)
- main uses of path
- seasonal variations in traffic
- types of transport that need to use path
- seasonal variations in problems
- observations on causes of problems
- what has been tried, why did it not work
- discuss and agree possible options

Prepare Preliminary Proposal (Technical Work)
- type and level of traffic to be designed for
- design standard to be used
- improvements and new construction needed
- possible options and preliminary estimates of resources needed

Planning and Design Meeting (Liaison with Community)
- discuss proposal and agree what is feasible
- agree priorities
- agree detailed work programme to be prepared

Carry out Detailed Design (Technical Work)
- select and design improvements/ construction to be carried out
- specify steps and details in work to be carried out
- estimate resources needed
- specify ongoing maintenance programme that will be needed

Meeting to Agree and Finalise Programme of Work (Liaison with Community)
- work programme to be carried out and schedule
- resources to be provided by community
- strategy on obtaining resources which cannot be provided by community
- ongoing maintenance to be carried out by community

Prepare Contract for Agreed programme of Work and Inputs to be Provided

2.1 WORKING WITH THE COMMUNITY

2.1.1 INTRODUCTION

This section starts from the assumption that the community has already organised itself with an effective and representative ‘footpath’ group, which has the strong backing of the community and is able to mobilise the required inputs from the community to improve its path and tracks.

If this is not the case then provision of technical assistance will need to be delayed until this is achieved. To check the acceptance of the group to the wider community a number of criteria can be used:

a) The members of the group are from different sections of the community, i.e. young/old, men/women, elite/non-elite, village officials/non officials, etc.
b) The group should have some legal status, i.e. be a committee under the village council or be recognised by the village authority.
c) The members of the group are actually recognised by other members of the community.

It is also highly desirable that there is some institutional recognition that the community owns and is responsible for footpaths that are to be improved.

Working with a community can be a difficult and time-consuming process. However, many mistakes have been made in the past because of inadequate liaison and planning with the community, resulting in inappropriate infrastructure and waste of effort.

It is essential to remember:

1. The community is the client for the work. They have to provide the inputs and sacrifices and live with the outputs of the work.

2. The aim of technical assistance is to correctly identify the needs of the community and provide the best possible advice and guidance to the community on these. However, the community must make the final decision on what is to be done.

3. The priority activities of the community are concerned with subsistence and survival. Work on improving paths has to be fitted in around these activities.

An essential starting point is to have a well mapped out strategy for working with the community to ensure there is proper consultation and agreement on all issues. A guide on this is shown in Box 2.2. The box sets out issues that are institutional/organisational and of a more technical nature to be discussed during group work or carried out by individuals in the interim.

To make the process of working with the community effective and meaningful there are a few key issue that apply to liaison and meetings with the community. These are discussed in this section.

BOX 2.2: STRATEGY FOR WORKING WITH THE COMMUNITY

Stage	Issue	
	Institutional/community	**Technical**
Initial meeting	Introductions Identification of existing body or setting up of new body to represent the community.	Setting out of planning process. Initial introduction to community transport system – paths, roads, modes of transport, services.
Interim work	Set up representative organisational structure.	
Planning meeting	Identify strengths and weakness of the community – financial, technical knowledge, tools, etc. Rank priority constraints and identify methods and resources to alleviate them.	Through a participatory mapping exercise identify key constraints in the transport system– path problems seasonal problems, slopes, poor access for animals and IMT . Rank priority constraints and identify methods and resources to alleviate them.
Interim work	Investigate willingness of community to contribute resources.	Prepare technical designs and estimate resources needed.
Design meeting	Discuss options for path improvements and resources needed. Decide on options to be chosen and how to resource these.	Discuss/amend technical design options for improvements including maintenance implications. Discuss work programme
Interim work	Start to mobilise the community and discuss organisation of work.	Prepare final design and list resources needed.
Final design meeting	Decide on how to obtain resources. Agreements made between bodies on resources and sourcing .	Decide on final design and resources needed. Agree programmes of work

2.1.2 PROGRAMME FOR PLANNING PATH IMPROVEMENTS WITH THE COMMUNITY

Initial Meeting

There should be continual liaison and consultation with representatives of the community to obtain information on footpath problems and guidance on improvements to be carried out. However the collaboration will be guided by a series of meetings which will be important steps in developing the work programme.

The initial meeting is very important in setting up the relationship and ground rules with the community group. If there is an existing committee the initial meeting should be with them, if not it should be with representative selected members.

The meeting should start with introductions from each of the community members and the project team.

If the committee is an existing committee the representation of the committee for the planning of footpaths should be discussed. Are there enough women on the committee, are there any business people who use the footpaths regularly, etc. The essential thing is that the group that plans the footpath, should include a good selection of people who regularly use the footpath.

The project team should then set out the planning process as described above in Box 2.2. A clear indication of the amount of time required for each meeting and timings should be set.

If the initial meeting has gone smoothly and the community group is considered representative of path users, then it is possible to continue into the planning meeting. If not the planning meeting should be put off for one or two days.

Planning Meeting

Before the actual planning starts the community group should now include a good representation of the community members who use the footpaths and are accepted by the community.

The first step in the actual planning process is to assess the transport situation in the community. This can be done in a simple participatory mapping exercise. This is essentially a sketch diagram on the ground or a large piece of paper to show the main elements of the community's geographical area. Obviously roads and footpaths should be included as well as rivers, marshy areas, houses, schools, clinics and other points people travel to such as farms and markets. The map does not have to be detailed or accurate, the important things are that community member draw the map and it enables all present to have an understanding of the transport system in the community.

The constraints to transport can then be discussed in the context of the whole community. It should be noted that the whole group needs to be involved as one person's constraint may be different to another's.

From this process it may be apparent that some of the transport constraints are not due to footpaths. If so, the group may pass it on to other committees or try to seek help from another source.

The constraints due to poor footpaths should be listed out and then ranked in order of priority to the community. This ranking can be simply done by scoring each option out of ten – ten for most preferred one for the least. This could also be expanded to include more objective criteria for example number of people served or number of services it serves.. At this point it would also be good to have a walk to the constraint points to discuss problems and improvements needed on site.

A discussion can then be held on what solutions there are to these problems. Consideration should be given at this point as to the level of current and expected traffic. If the traffic includes wide two wheel vehicles such as hand carts, the design will be different to that used by pedestrians and cyclists. The sustainability of the surface will also have to be considered as motorcycles will wear the road more than bicycles. Finally a discussion on the extent of the improvements, for example does the whole footpath need improving or is it just one spot such as a bridge or muddy section to enable access.

This obviously brings in resource constraints and these can be discussed in terms of what skills, money materials and labour are available form the community or other sources. No definite amounts need to be discussed, although the technical advisor may be able to give a rough estimate as to the amount of materials and labour required and their cost.

A discussion can then be held regarding resources and inputs that can be provided by the community and help that can be given by the technical assistance. This will clarify the ranked options in terms of what appears feasible and what is not feasible. It may not be necessary at this point to have only one option as the committee may want to discuss this with the wider community along with resource implications.

Design Meeting

This meeting is where the options for improvements are discussed and those to be carried out agreed. The technician should present outlines of a number of options for the community group to discuss, based on the previous planning meeting and design studies carried out since the meeting.

The presentation should be done in a way that the community group can understand. Well explained technical drawings may aid understanding, but, a visit to the site plus technical drawings is the best way to show what has been designed. The guidelines and drawings presented in Chapter 3 of this manual are aimed at providing the information needed.

The estimated resources (time, money, labour, materials, skills) needed to complete the work should be clearly outlined.

There should also be a discussion on the future maintenance of the improvements and the resource implications for the community. This should emphasise the need for ongoing maintenance to preserve the improvements to the paths and that without this maintenance all the time and effort put into improving the paths will be wasted.

From the presentation a discussion can be held on each option. A consensus should be reached on the options to be chosen. It may be that none of the options are acceptable and further changes need to be made. However, the technical advisor should try to ensure that these are changes within chosen options, rather than new options.
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Following the selection of options the proposed timetable for the works can be discussed. The technical advisor can also introduce the community contract for the works. An example of a contract is given in Annex 2.

Final Design Meeting

The final design meeting is when decisions are made on the chosen options and a contract can be agreed and signed. To make this happen the technician should have completed all final details of the designs and the committee should have discussed the design options and the resource implications with the wider community.

The final designs for path improvements, resource requirements, proposed programme of work and ongoing maintenance should be clearly explained. Full discussion and understanding of these should be encouraged. Hopefully if previous discussions have been clear this should not be a long process.

The contract between the community and the technical assistance organisation can then be signed. This should include:

- Documentation of the improvements to be carried out, drawings with explanatory notes and instructions on the work needed

- A bill of quantity of all resources to be provided and their source

- Full details of inputs to be provided by the community

- Details of ongoing support from the technical assistance input

- Details of the programme of work including methods of supervision, monitoring and recording.

- Agreement for ongoing maintenance by the Community with details of the programme to be carried out.

An example contract is given in Annex 2.

To seal the contract and raise awareness through the wider community it may be appropriate to make the contract signing into a community celebration. Other persons such as local administration leaders should be invited to this celebration to add status to the proceedings and increase rapport with the community.

2.1.3 CONDUCTING COMMUNITY MEETINGS

Behaviour and attitude are very personal attributes, which can often be deeply ingrained and unchangeable. They affect the way you look, speak and basically communicate with people.

When working with communities the environment created should be one in which people feel free and able to communicate the sharing of information. The attitude of professionals and community members will greatly affect this environment. Common things to look out for are:

Appearance

Before you say anything to community members they will already have a preconception of who you are, how you will behave, what you have come for, etc. We all do it and the saying 'first impressions last' holds true in many cases. Appearance not only covers clothing but also cars, bags, etc. During a meeting it may be hot especially if walking to sites. Simple light informal clothing can be more comfortable, as well as making people more approachable and easy to talk too. Jewellery and other accessories, such as bags can also send out status messages, which can create barriers to good communication. Try to create a workmanlike and approachable appearance.

Is this the right first impression?

Respect

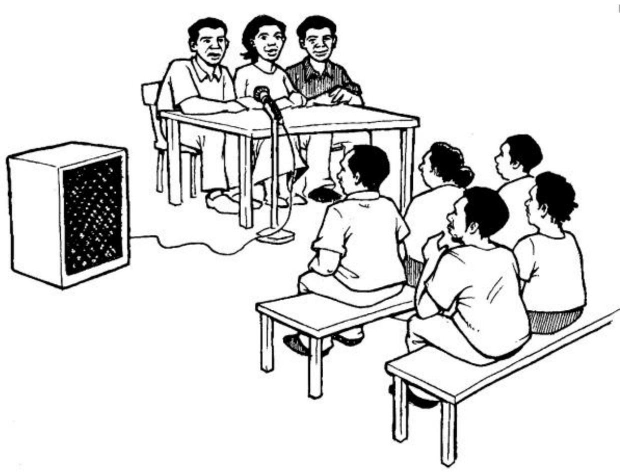
Professionals have gained status through education and experience. This should bring respect but not superiority. Equally the knowledge that a community member has about their local area, their skills and work also has to be respected. It is important that this respect is maintained on both sides. One of the most important elements of respect is listening to people and allowing them to have their say.

Meeting times

Community members are people with jobs and families to care for, they are not just there to assist the project. Meetings should be pre-arranged well in advance and at the convenience of the community members. This may mean having meetings in the evening or early morning.

Meeting space

The majority of meetings should be held within the community and organised by the community. The seating arrangement should be one that encourages everyone to participate, particularly when maps and sketches are being prepared or viewed. Sitting in lines often means poor participation by those at the back. Semi-circles or circles are often best.



Who is participating?

Group Participation

Different personalities in a community group can greatly affect the type and quality of information that is shared in group discussions. Within most groups there will be a dominant person, a ”gatekeeper”.

A gatekeeper through his/her domination will control the information that is brought out in a meeting. These people are usually the ‘important’ ones in the community and so need respect. However, being the most important does not mean that they are the most knowledgeable.

Women are often shy to participate in meetings, however, they are often the most frequent users of footpaths.

It is the advisor’s job to make sure that everybody is encouraged to have a say and contribute to the discussion so that all the facts and issues are covered and the consensus of the opinions of the community is brought out.

Some simple techniques to aid good participation are given below:

- Make sure the space is well set out as mentioned above

- Get people to introduce themselves so everybody has talked from the start.

- Limit the number of people to key representatives of the community. For example local leaders, women, men, old, youths, business people. Ideally the group should be no bigger than 20 and not smaller than 10. Wider community meetings can be used to present ideas rather than discuss ideas.

- If people are not involved in the discussion a simple “What do you people at the back think?” will start to involve them.

- A ‘gatekeeper’ should be listened to but by asking other members of the group to comment on what the gatekeeper has said will start to dilute the domination of the gatekeeper.

- It may be appropriate to establish a women's and a men's group separately. This will enable views from both sexes to be openly heard. There can then be a joint meeting to compare and further discuss issues.

- The use of visual techniques such as mapping, will obviously aid participation as people usually want to become involved.

- Targeted questions can be useful to involve others, for example ‘What does granddad think about getting up the footpath steps?’ this can exclude gatekeepers and include silent groups.

- If all measures proposed to reduce domination of a gate keeper fail, a request for a one to one discussion can be useful. Removal of the gatekeeper, makes them feel important and allows the rest of the group to start talking.

2.1.4 OTHER IMPORTANT ISSUES

Raising Hopes

From the beginning of the planning process it should be clear what is available from each side. The community should state clearly what resources it has available and what inputs it can provide, whilst it should be made clear to the community what can be provided through the technical assistance input. By marking out the boundaries from the start it will hopefully reduce the risk of expectations being raised too high.

Keeping Records

The majority of community committees will have a secretary. Minutes should be kept for each meeting. The key elements will be records of agreements made between the groups, this especially applies to resource commitments, such as money, materials or labour. As the works continue this will obviously be made in the form of contracts, but it is important to record the initial steps in the planning process as well.

Keeping records avoids disputes!

Creating the Right Environment

The attitudes, behaviour and tips outlined above are key in establishing a good first impression and enabling an environment in which all the members of the community feel they can contribute to the design of their footpath. The key words to think about when working with communities are.

The Right Attitude	The Right Behaviour
• Openness	• Sharing
• Humility	• Be friendly
• Curiosity	• Show respect
• Acceptance	• Listen carefully – don't lecture
• Sensitivity	• Admit error
• Flexible	• Be encouraging

2.1.5 GUIDELINES ON IMPLEMENTATION

Organisation of Work Programme

One of the first issues to clarify with the community when planning the work programme is exactly how many work-days can be provided over a period of time and when these are available. For instance, how many work-days can be provided per month over the year. This should be broken down into unskilled (general labour) and skilled (carpenters, stone masons, builders and other crafts persons).

Most of the work will be voluntary so it has to match people's availability. Experience suggests that people are prepared to give about one month, 25 to 30 days, of voluntary input in a year. If the inputs stated by the community representatives are higher than this they should be carefully checked with the footpaths committee. This is particularly the case if large inputs of women's time are specified. Women already have heavy domestic burdens and should not be expected to provide full days of labour inputs.

In some cases there may need to be a large continuous input of labour, particularly skilled labour, which is difficult to provide from voluntary inputs, for example, building a footbridge. This will mean working out with the community whether it is possible to pay for the labour. This will probably require some form of community "tax" which will need to be explained and organised by the community authorities. Some people may prefer to make monetary rather than labour contributions.

Once the availability of labour is known this can be matched against the prioritised list of improvements to be carried out to prepare the schedule of work. Each improvement needs to be broken down into a detailed list of activities and the labour requirement for each activity estimated, both type of labour and number of workdays. From this a weekly schedule of work and targets can be prepared.

The work programme will need to be approved by the community who will have the final say on what is acceptable. When this has been achieved a written contract should be drawn up.

The organisation of the work programme and mobilisation of the inputs needed are the responsibility of the community who should provide gangleaders to supervise the work. However it will be helpful to discuss ways of motivating the workforce and achieving good quality of work. One approach is to organise the labour in groups or teams that have some form of identity, for instance based on family, living location or some other linking factor. Groups with an identity are more likely to develop a pride in their work. A friendly, competitive environment may be created, possibly even with rewards.

Technical Assistance to Implementation

The inputs from technical assistance may include:

- Assistance with setting out the work
- Issuing instructions to gangleaders
- Providing on-the-job training where this is needed
- Advising and problem solving

- Monitoring the work to check that it is carried out correctly and to the required standard

Issuing Instructions

It is probably best to set tasks on a weekly basis during busy work periods and on a 2-weekly or even monthly basis during less busy times.

Task rates should be fair taking into account the nature of the work force but must make sure work is completed efficiently. If work is allowed to drag on for too long, early work may deteriorate requiring tidying up or even re-doing which requires extra time and effort.

Clear instructions should be given to the community persons responsible for supervising the work, using sketches and concise notes. The guidelines presented in Chapter 3 are intended for this purpose and should be used as much as possible.

Issuing instructions should include explanations on site to point out details and features. This may include installing pegs or stakes to mark out the work.

Where similar work has been carried out nearby it will be useful to visit this to clarify what is required.

Training

The amount of training needed will depend very much on the previous experience of the work force and particularly of the gangleaders. Techniques such as stone laying, compaction and profile checking are most likely to require training. However, even with the more common tasks such as excavation and levelling, the workers may not use the best tools or techniques and some training may improve the efficiency and quality of work.

It will be most effective to train the gangleaders. An initial course of on-the-job training is recommended to make sure that all the gangleaders are able to do the work properly themselves before supervising others (it is recommended that gangleaders are working supervisors rather than just supervisors). This can be followed up with early visits to site to view the work and to decide what further training is needed.

It is also important to make sure that training covers ongoing maintenance. When improvements have been completed, training courses should be held for the community gangleaders who will be responsible for supervising ongoing maintenance of the improvements.

2.2 GUIDELINES ON TECHNICAL PLANNING AND ORGANISATION

The main steps involved in planning and organising the technical work are listed in the introduction to this chapter and in Box 2.1. This section now deals with these in sequence in more detail.

2.2.1 DETAILS, FUNCTIONS AND USERS OF THE PATH/TRACK

Much of this background information can be obtained from the initial meeting with the community. At this stage the community will have decided on the footpaths that need to be improved and the help they need. The information required for planning is:

1 **Details and Functions of the Footpath**

- The route of the path – get the community group to draw a map on a large sheet of paper; mark on the main features of the path and the terrain. Collect any maps available from District authorities

- What are the access problems along the path where it is considered that improvements are needed – mark these locations on the map. Identify the seasonality of these problems, for instance when the problem occurs and, on average, for how many days in the year

- What are the main functions of the footpath? i.e. which sections of the community does it serve, roughly how many people is this and what facilities does it provide access to

2 **Details of the Users of the Footpath**

- It is important to get accurate and reliable information on both the types of users (walkers, bicycles, carts etc.) and also the numbers of each type, as this data will determine the design standard needed for the path. For instance it is a waste of effort to construct a wide path if it will only be used by people walking whereas if only a few carts use the track a width of at least 2m will be needed

- It is therefore essential to get clear specifications from the community on the range of users that the path has to be designed for. The implications of different types of users should also be clearly pointed out i.e. what type of path is needed for bicycles, what is needed for carts etc. This is particularly important if there is any demand for motorised vehicles to use the path or track. Point out the extra requirements needed and the large damage that can be caused by a heavy vehicle which can then make access difficult for other users

- If it is clear that the path or track is heavily used by a range of different types of users then it may be worthwhile to carry out traffic surveys to get more accurate data on the level of use of the path/track. Guidelines are given on the next page

Note: It is important to keep a clear and accurate record of all information, decisions and agreements. It is recommended to keep a logbook.

Traffic Surveys

Traffic surveys are required to find the number and type of users passing along a path. The information collected can be used to select the paths that should be improved first and the type of path to be provided.

The following list outlines the information that should be collected during a traffic survey.

1. Number of users per day

2. Origin and destination of users and how frequently (times per week) they use the path at different periods of the year. (if the path is very busy a smaller sample of travellers may be asked these questions)

3. Type of user e.g pedestrian, bicycle, animal cart etc

4. Male or female

5. Child or adult

6. Type, and weight of load

The following guidelines should be followed when planning a traffic survey.

- Does any traffic data already exist? e.g. with the local planning department

- The traffic will probably vary during the day with peaks early in the morning and middle to late afternoon. Dividing lines at 2 hour intervals in the traffic count boxes will allow the variation and peak rates to be estimated

- Traffic will vary during the week. A Market day in a local centre can cause a large increase in traffic. Surveys should therefore be carried out on at least two days of the week, the busiest day and an average day

- There will also be seasonal variations in traffic levels with peaks occurring during the harvest season. Information on this will need to be obtained from local informants

- Survey points should be positioned clear from large villages to prevent the counting of people undertaking local internal trips

- Some paths may have short alternative routes that will distort the true number of travellers. Survey sites should be chosen to ensure all travellers are counted

- Water crossings such as bridges are good survey sites

- Two persons will be needed, one to count traffic and the other to carry out spot interviews

EXAMPLE OF TRAFFIC COUNT SHEET

PATH/TRACK: From………….. To………….. Location of count………

Date…………..Time: From……….. To………….. Name……………………

<table>
<tr><th colspan="2">Type of Traffic</th><th colspan="2">Going To:…………..</th><th colspan="2">Coming From:…………..</th></tr>
<tr><td rowspan="3">Walking without Load</td><td>Man</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Woman</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Child</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="3">Walking with Load</td><td>Man</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Woman</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Child</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="3">Bicycle without Load</td><td>Man</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Woman</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Child</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="3">Bicycle with Load</td><td>Man</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Woman</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Child</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td rowspan="3">Bicycle with Passenger</td><td>Man</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Woman</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Child</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Wheelbarrow</td><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Hand/Cart</td><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Sledge</td><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Ox-Cart</td><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Donkey/Cart</td><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><th>Motorised</th><th colspan="2">Passenger</th><th>Goods</th><th>Passenger</th><th>Goods</th></tr>
<tr><td>Motorcycle</td><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td>Car/4 WD</td><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td>Light Truck</td><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td>Tractor/Trailer</td><td colspan="2"></td><td></td><td></td><td></td></tr>
</table>

Notes: Light truck – less than 5 tonne;

Place a mark in the box for each unit	~~IIII~~

2.2.2 DESIGN STANDARDS

The design standard for the path or track will depend on the number of users and their mode of transport.

1. What is the number of users per day or hour?

2. What types of load are carried?

3. Do pack animals use the path or track, with or without carts?

4. Do wheeled vehicles such as bicycles use the path?

Note: It is essential to clarify and agree with the community the numbers and types of users that the path must be designed to take, as this will set the standard for the minimum width and bend curvature needed for the path and the maximum allowable gradient.

It is particularly important for the community to decide whether vehicles such as handcarts and animal-drawn carts will use the path as this will require a minimum design standard which may considerably increase the amount of work involved in improving the path or track.

The four most important design standards are:

- The width of the path
- Clearance above the path
- The gradient of the path or track (Section 3.4)
- The surfacing of the path or track

Width of path: This depends on the number of users and type of traffic. Guidelines are given in Figure 2.2. The path should be designed for the average peak traffic that occurs over the busy time of the year.

Clearance above the path: The minimum cleared height that will allow head loading is 2.2m and bicycles is 2.5m. The recommended clearances for different paths are shown in Figure 2.2. If horse-riders use the path, a clearance of about 3m will be needed.

Bend curvature: This becomes important if vehicles use the path. A minimum bend radius of 2.5 m is needed for bicycles and 5m for animal drawn carts.

Gradient: The maximum gradients that can be comfortably climbed by different users are given in Section 3.4

Path surface: The requirements will depend on the type of transport using the path and the drainage of water away from the path. Improving the path surface is discussed in section 3.2

Figure 2.2: Proposed Design Standards for Different Paths and Tracks

Formation Width of Path

In most cases the path will need to have side drains. The total or *formation* width of the path therefore needs to include the width of drains and shoulders as shown in the table.

Width of Path		**1m**	**1.2m**	**1.4m**	**2m**	**2.5m**
Formation Width W	Drain Both Sides	2.5	2.7	2.9	3.5	4.4
	Drain Only One Side	1.8	2.0	2.2	3.2	4.2

2.2.3 TECHNICAL SURVEY OF PATH

The aim of this stage is to obtain detailed information on the improvements needed on the path or track and to identify the options for carrying out these improvements. It should include the following steps:

1. Walk the path with key informants from the community. For each of the problem areas along the path obtain information on:

   - The nature of the problem
   - Why they think it occurs
   - How it varies over the year
   - What has been done to try to solve the problem
   - What happened, why did it not work?

2. Record the details of the problem areas with sketches and notes. Take measurements of relevant distances and gradients. Record other relevant details such as the type of soil and features of the surrounding terrain, maximum flood levels, available materials (stones, timber, water etc.) and details of ownership and usage of adjacent land.

   If possible take photographs to show details of the problem area.

3. Identify possible options for improving the path (see Chapter 3 of manual)

   Make sketches of what will be involved in carrying out these options. Note what will need to be done and what problems may occur.

2.2.4 SELECTING AND DEVELOPING APPROPRIATE METHODS FOR IMPROVING THE PATH

Having identified the improvements needed for the path and possible methods for making the improvements, the next stage is to select and develop options to the stage where they can be presented to the community for consideration. In some cases more than one option might be chosen so that the community can decide which they prefer.

As indicated in Box 2.1 this will involve two main steps:

1. Preparation of proposal to community for improvements to be carried out

- The proposal should outline each of the proposed areas of improvement and the methods to be used. Guidelines and illustrations for this are given in Chapter 3 of the manual.
- The outlines should be in sufficient detail to show what is proposed (use sketches), what problems may occur and to allow estimates of resources needed
- Estimate resources needed – labour, materials, tools – and the costs involved. Guidelines on estimating inputs needed are given in the next section
- Outline the ongoing maintenance that will be needed to sustain the proposed improvements (see Chapter 5)
- The proposal should be presented at the *Planning and Design* meeting with the community for discussion and agreement
- The output of the meeting should be a written agreement on the programme of improvements to be carried out and the order of priority of the work.

2. Preparation of detailed work programme

- Full details of the agreed improvements to the path can now be worked out and estimates of resources needed checked
- Detailed specifications and instructions for carrying out the work should be prepared
- A detailed programme of work with weekly inputs and targets should be drawn up
- The detailed programme of work will form the basis of a contract with the community which specifies inputs from the community and from the technical assistance support. Inputs from other sources, for instance District Councils, should also be included and agreed
- The contract should also specify a programme of ongoing maintenance to be provided by the community

2.2.5 ESTIMATING INPUTS NEEDED

The proposal to the community on improvements to be carried out on the path will need to include good estimates of the inputs of labour, tools and materials needed to carry out the work.

Guidelines on these are given in the following pages as follows:

- Figure 2.3 illustrates the main steps involved in labour-based construction of paths and explains the method of measuring the quantities of work to be carried out.
- Figure 2.4 provides guidelines on the main excavation to be carried out – 1. Excavation to level, 2. Excavation of drains.
- Table 2.1 presents data on typical task rates for the various work tasks which has been collected over the years.
- Table 2.2 presents guidelines on the best methods of haulage of materials for a range of distances and estimates of the volume which can be transported per day.

The information from these figures and tables allows estimates to be made of the number of work-days of labour needed to complete the work to be carried out to improve the path.

Details of hand tools needed can be obtained from Section 2.2.6.

Excavation to level

(i) Across the path

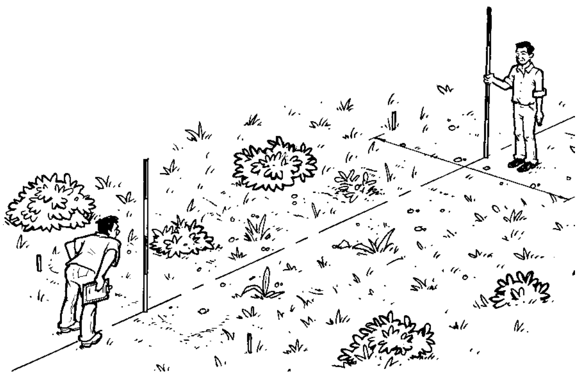
It is important to prepare a level bed across the formation width of the path. As a guide, slots about 0.5m wide are cut across the width about every 5 to 10m. The aim is to minimise work in preparing the level bed by balancing the cut against the fill.

(ii) Along the path

If the longitudinal profile of the path is very irregular due to humps and dips it may be necessary to smooth it out, especially if vehicles are to use the path. In this case the aim will be to balance the excavation of the humps against the fill in the dips to get a smoother surface. This can be done by eye. Because of the considerable work that may be involved it should only be done where necessary and to the least amount needed. This additional work will need to be included in the estimate of person work-days required to carry out the work.

Figure 2.3: Main Steps in the Construction of a Path

The following sequence of steps illustrates the main activities in labour-based road work for which estimates of labour inputs are needed.



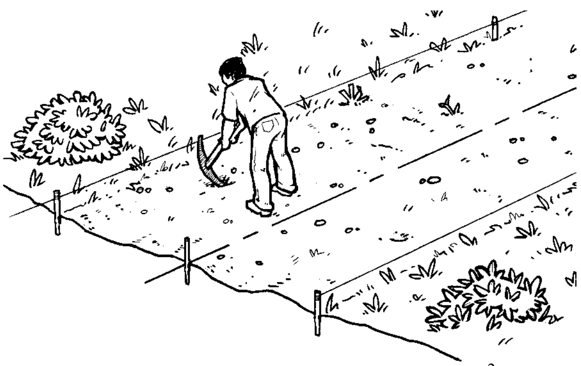
Quantity = length set out (m)

STEP 1: Setting Out The Path

Careful setting out of the alignment of the path is needed to produce a good quality path with the least amount of work.

In many cases an existing path will be followed, but there may be cases where it is necessary or easier to change the route.

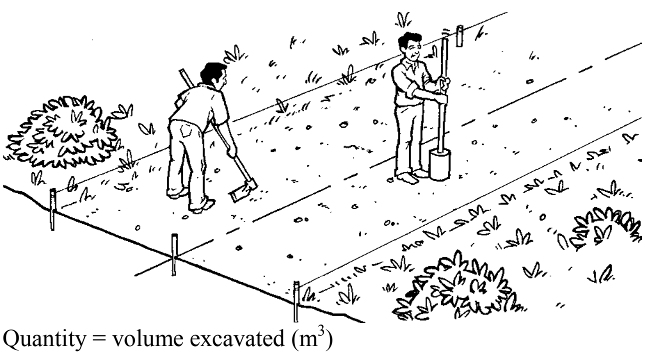
1.1 Mark the centre-line with poles at 5 to 10m intervals.
1.2 Measure *formation width* (see Section 2.2.2) of path and mark with pegs.



Quantity = formation width x length (m^2)

STEP 2: Clearing and Grubbing

2.1 Remove any rocks (avoid them wherever possible) from the formation width of the path.
2.2 Cut back all vegetation
2.3 Then dig out all bush stumps and grass roots ("grubbing").

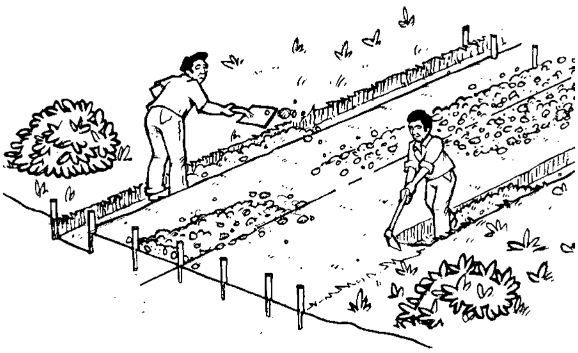


Quantity = volume excavated (m^3)
= Sum of areas at each slot (Figure 2.4) x distance between slots

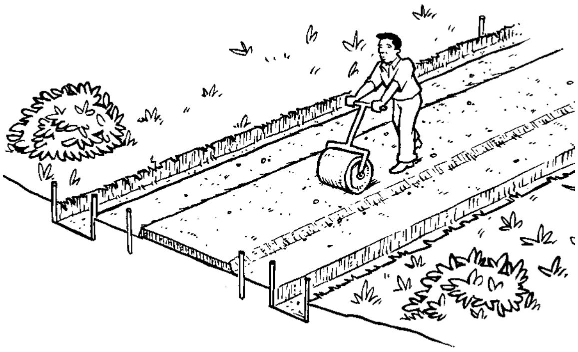
STEP 3: Excavate to Level

The aim is to provide a level base and minimise excavation by balancing fill with excavation.

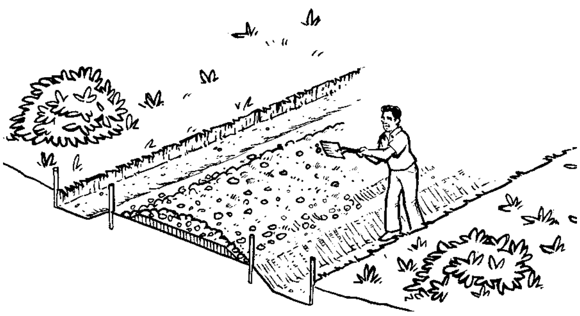
3.1 Cut slots about 0.5m wide at 5-10m intervals to provide a guide for excavation to level. These should balance fill against excavation (see Figure 2.4).
3.2 Complete excavation to level.
3.3 Water fill (if dry) and compact.



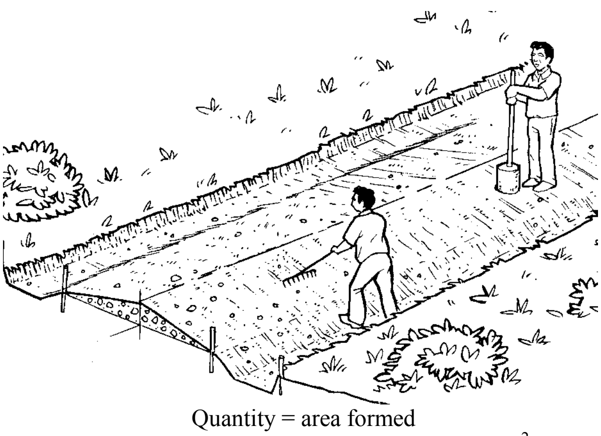
Quantity = volume excavated (see Step 6)



Quantity = area compacted
= width x length (m^2)



Quantity = cross-section area of drain (Figure 2.4
x length (m^3)



Quantity = area formed
= path width x length (m^2)

STEP 4: Mark Out and Excavate Drains

4.1 Use pegs and string to mark out drains (see Figure 2.4)
4.2 Excavate drains – throw soil to centre of path.
4.3 Use slope template and spirit level (or posts, string and level as on page A4-4) to check slope of drains

STEP 5: Formation of 'Plug'

5.1 Spread the excavated material over about ¾ of the width of the path surface to form the 'plug'.
5.2 Water and compact the plug.

Note: hand compaction can be used but a hand roller will save considerable time and effort.

STEP 6: Sloping of Ditches

6.1 Excavate the slopes on each side of the ditch and throw the soil onto the 'plug'.
6.2 Use a template (Figure 3.3) to obtain the correct slopes and shape of the drain (Figure 2.4).

STEP 7: Formation of Camber

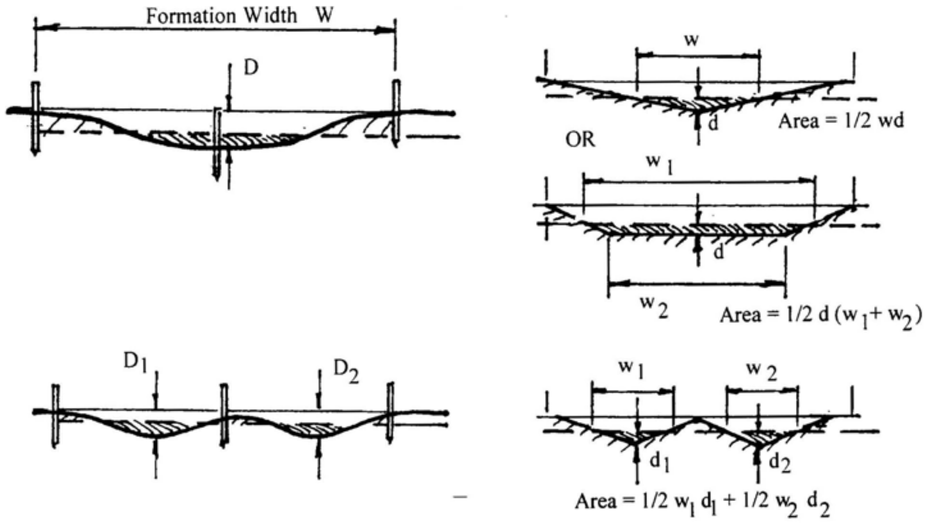
A good camber is essential to ensure that rainwater flows off the surface of the path.

7.1 Spread material to initially form a camber with a cross-fall of about 8%.
7.2 Water and compact the soil either using a hand rammer or hand roller (if one is available). The cross-fall after compaction should be about 6%.

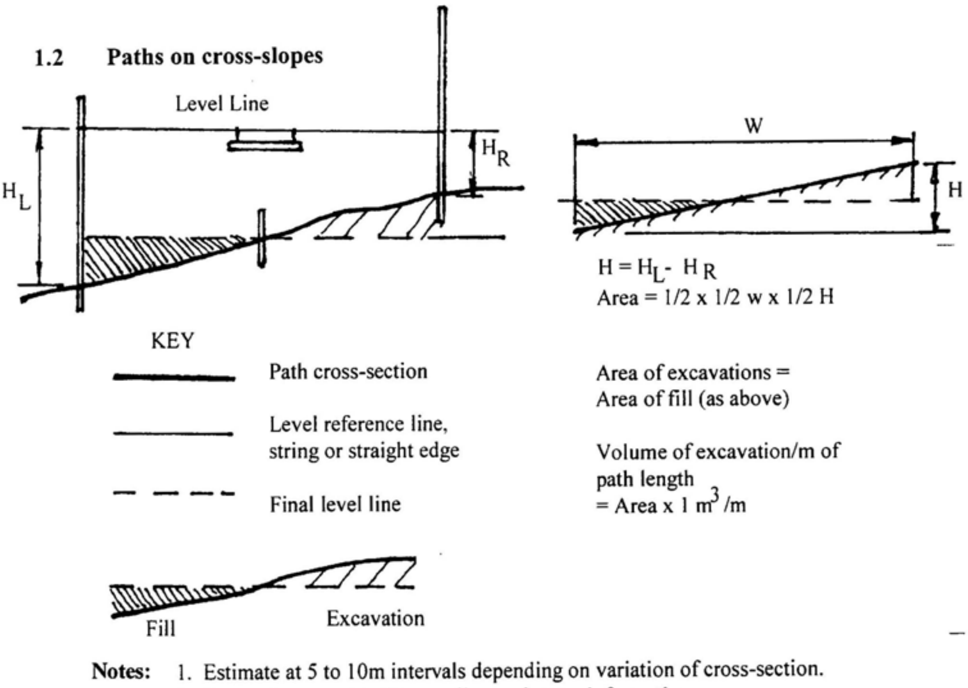
Figure 2.4: Estimating Volume of Excavation

1 Excavation to Level: Aim is to balance excavation and fill and produce a level bed across the formation width (path and drains) of the path.

1.1 Paths on Level Ground



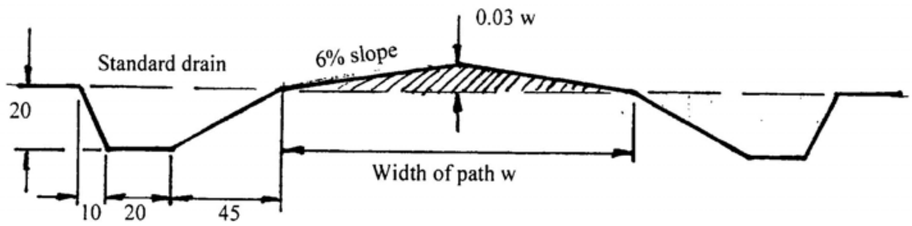
1.2 Paths on cross-slopes



Notes:
1. Estimate at 5 to 10m intervals depending on variation of cross-section.
2. Approximate method is usually good enough for paths.
3. Areas may also be estimated from slots cut prior to levelling.

2. Excavation of Drains

Standard Cross-Section of Path



Aim is to balance excavation of drains with fill needed to form the camber.

Cross-sectional area of camber = 0.5 x w x 0.03 w = 0.015 w^2

Allow extra 30% for compaction, area of fill = 0.02 w^2

Width of path, w (m)	1	1.2	1.4	2.0	2.5
Area of Fill (m^2)	0.02	0.03	0.04	0.08	0.13

Area of standard drain shown in sketch = 0.09 m^2
Area of 2 drains = 0.18 m^2

- This means that for paths with side drains each side the volume of soil excavated from the drains is more than adequate to form the camber for path widths up to 2.5m.

- For paths with a side drain on one side only the drain size provides adequate fill for the camber for path widths up to 2m. For a 2.5m wide path, the depth of the drain should be increased to 25cm with the same shoulder slopes.

Task Rates

Guidelines on task rates (the amount of work that will typically be completed by one person in a day) are shown in the table below.

Table 2.1: Typical Task Rates for Labour-based Road Work

Activity	Unit	Daily task Rates
Setting out of centre line and marking formation width of path	m	100
Removal of boulders/excavation of rock	m^3 (loose)	0.5 to 1.0
Clearance of grass, bush, incl. Grubbing	m^2	50 (heavy – 150 (light)
Cutting of slots and setting of profiles (Based on formation width x length)	m^2	600(hard soil) – 1200(soft soil)
Excavation to level or side borrow (1)	m^3	3.0 – 5.0
Ditching and spreading	m^3	3.0
Sloping	m^3	3.5
Camber formation	m^2	100
Compaction by hand	m^2	100
Excavation and stocking of gravel	m^3	2.0 – 3.0
Loading and off-loading of gravel	m^3 (loose)	8.0 – 12.0
Spreading of gravel to camber	m^3 (loose)	10 to 15
Collection of sand/gravel	m^3 (loose)	0.5 – 1.0
Stone/rock collection	m^3 (loose)	1.0
Crushing stones/rock	m^3 (loose)	0.15 (small pieces, 5 to 40mm) to 0.5
Lay dry stone masonry (construction) Volume = length x width x height	m^3	1.0
Lay stone pitching – area = length x width	m^2	2.0 to 4.0

Notes:
1. All rates for excavation are for digging and throwing only. For additional movement of material add haulage time.
2. Range of task rate indicates "difficult" to "good" conditions.

Collection/Haulage

In most improvement or construction work on footpaths there will be a need to move or transport materials, mainly soil, gravel and stones, although every effort should be made to keep this to a minimum.

Note: in collecting material for the path surface, include an extra 30% to allow for compaction.

Guidelines on the most appropriate methods of haulage for different distances and the typical rates that can be achieved are given in the following table:

Table 2.2: Guideline on Methods of Haulage

Haulage Distance	Method and Typical Rate per Person
Up to 10m	Shovelling or raking – typical rate for movement of 10m is 3 to 5 m^3 per day
Up to 50m	Carrying in buckets, baskets or on stretchers. Assume 25kg/trip and 3km/hr on flat, 2km/hr uphill – remember time for return trip and loading/unloading. Typical rate for 50m distance on flat ground is 1.5 to $2m^3$ per day
10 to 150m	Wheelbarrows are best if terrain is suitable – they are not suited to rough ground and above medium slopes. Assume $0.05m^3$ per trip and other factors as above for carrying. Typical rates on flat: 50m – 3 to $4m^3$ per day 100m – 2 to $2.5m^3$ per day
150 to 800m	Animal drawn carts are best if there is suitable access and slopes are not too great. On flat assume loads of $0.16m^3$ for single donkey cart, and about $0.4m^3$ for pair of oxen. Average speeds as for walking. Considerable time will be needed for loading and unloading. Typical rate for ox-cart on flat for 500m distance would be 2.5 to $3.2m^3$ per day
Over 800m	Difficult to justify hauling materials this far for a footpath. Consider these cases very carefully.

Note: The typical haulage rates in the table *include* estimates of loading and unloading time. However, they *do not* include time for excavation and stocking.

2.2.6 HANDTOOL REQUIREMENTS

There are a wide range of handtools, outlined in the table below, that may be required for footpath construction and maintenance

25m Tape Measure	For setting out centreline, etc
5m Tape Measure	For setting out cross measurements
Sisal rope (kg)	For setting out
Ranging and boning rods (with profile boards)	For setting out
Line Level	For setting out
Straight Edge	For setting out and measurements
Spirit Level	To be used in conjunction with templates
Nylon String, Rolls	For masonry works
Slasher	mainly used for grass cutting and clearing small bushes
Bush Knife	mainly used to clear light overhanging tree branches and shrubs
Axe	general clearing and cutting down trees and removal of tree stumps
Crowbar	for boulder removal
Bow saw	cutting small branches and larger trees
Cross cut saw	clearing fallen trees (substitute for a chain saw)
Hoe	general excavation in light or medium soils
Pick axe	excavation of heavy soils and weak rocks
Mattock	for cutting through roots
Shovel	used to throw excavated material
Hand Rammer – 10kg & 15cm round or square	For compaction of loose soil and gravel
Smooth Steel Drum Hand Roller	Desirable for compaction of large areas
Ditch Template	To control shape of ditch
Rake or Spreader	To spread excavated material and laterite
Camber Board	To control correct camber formation
Watering Can with Spray	To distribute water before compaction
Wheelbarrow	movement of material over distances up to 200m
Head basket	movement of material for short distances
Bucket	movement of material for short distances
Stone chisel	dressing stone
Light hammer	fixing nails and dowel in structures
Sledgehammer	for driving in posts
Winch (Tirfor)	positioning of bridge elements during construction
Trowel	construction of stone masonry
Spanners	to fasten bridge elements e.g. clamps on suspension bridges.
Head Pans or Karai	To transport mortar or concrete
First Aid Kit	To deal with accidents
Sharpening Stone	To sharpen tools

The following set of tools should be provided for each labour gang. This set is adequate for a gang of 10 to 15 persons. Additional tools will be required for more specialist activities.

Labour Gang Tool Set	
6 Hoes – jembes	6 rakes
6 Machetes – pangas	3 pick axes
3 Slashers	3 mattocks
6 Axes	2 sledgehammers
6 Shovels	2 crow bars
6 karai / head pans	2 sharpening tools

Figure 2.5: Checking Levels and Setting Slopes

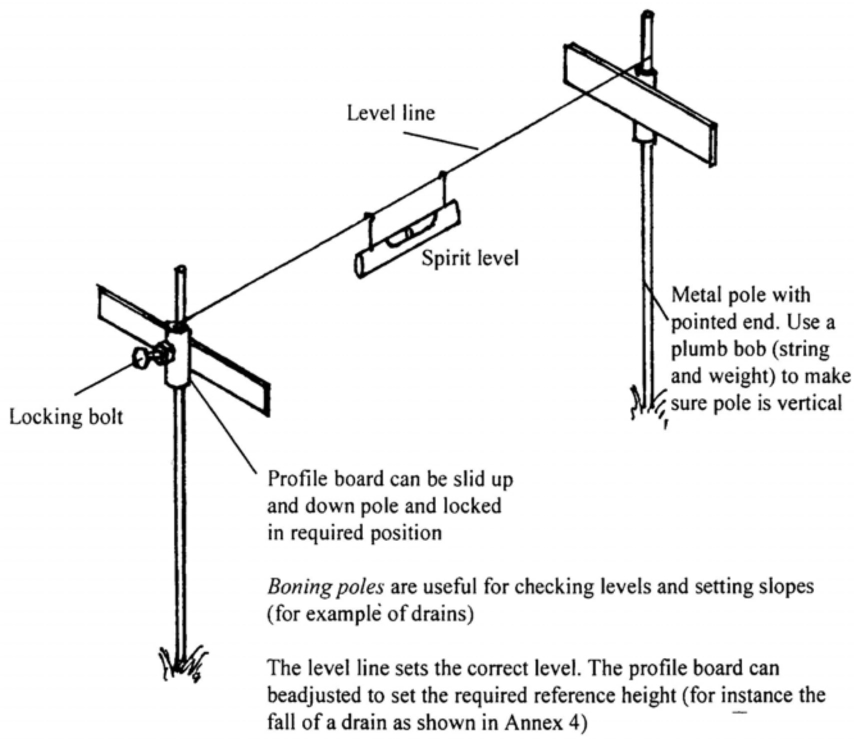
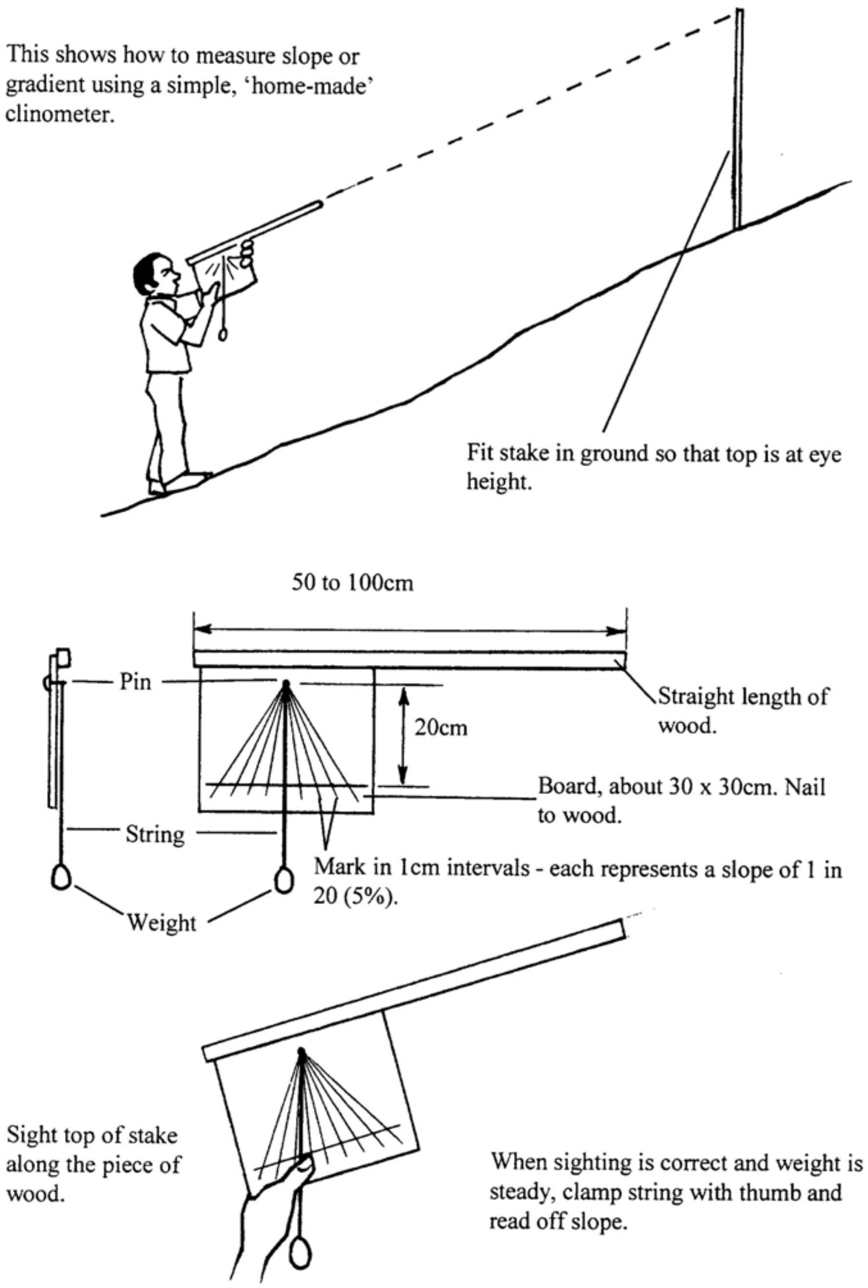


Figure 2.6: Measuring Slope



2.2.7 ENVIRONMENTAL CONSIDERATIONS

Because of their relatively minor nature, footpaths are unlikely to have significant environmental impact but nevertheless good environmental practice should be used in their construction and improvement. This should include:

- Outlets of drains should be carefully constructed and located to avoid erosion or damage to vegetation. The water flow should be spread to reduce flow rates and to allow the water to sink into the ground

- If fill is imported from borrow pits, level and regrass these on completion of work so that the area is returned to its original state

- Use natural methods to minimise erosion. For example, regrass shoulders and drains to protect soil from being washed away

- Natural methods can also be used to protect fragile slopes against erosion and landslides. Plants or small bushes with deep spreading roots can be planted to bind soils and prevent erosion. These may need to be carefully developed before planting and also protected until they establish themselves in the soil. Wooden stakes driven firmly into the ground can be used to anchor the plants until they are robust enough to support themselves.

In designing improvements to footpaths, every effort should be made to use methods that protect or enhance the local environment and the community encouraged to take a similar approach.

3. DESIGN AND CONSTRUCTION

This chapter gives technical guidelines on design and construction of paths. These apply to spot improvements and construction of new paths.

The first section covers the setting out of the path. The subsequent sections cover the common problems which may have to be dealt with.

It should be noted that in most cases the work required will be for 'spot improvements' to relatively short lengths of existing paths rather than construction of new paths.

Alignment and setting out of standard designs for paths and drains for different terrain are covered in *Section 3.1.*

Additional or alternative construction to deal with particular problems are covered in subsequent sections as follows:

- *Improvement of path surface – Section 3.2*

  The existing soil may not be suitable for a path surface and may need to be improved by a layer of material brought from elsewhere.

- *Additional or improved drainage - Section 3.3*

  Additional drains may be needed to get water away from the path and the side drains. Improved drains may be needed in areas of high rainfall and runoff.

- *Paths in hilly/mountainous areas – Section 3.4*

  Zig-Zag paths may be needed to keep gradients within acceptable limits for traffic using the path. Where this is not possible then steps may be needed. Paths on steep slopes are particularly affected by high water run-off and erosion. Additional construction works may be needed to deal with these problems.

- *Paths over marshy ground – section 3.5.*

  Particular techniques are needed to provide a solid and stable path

- *Water crossings – section 3.6*

  This section deals with carrying drainage run-off across the path as well as the crossing of small streams. It does not cover footbridges which are a more specialised issue and are dealt with separately in Chapter 4.

3.1 ALIGNMENT AND SETTING OUT

If the path is to be realigned or a new section of path constructed the first steps will be to choose and clear the route. Try to avoid obstacles such as trees, bushes and rocks as far as possible in choosing the route.

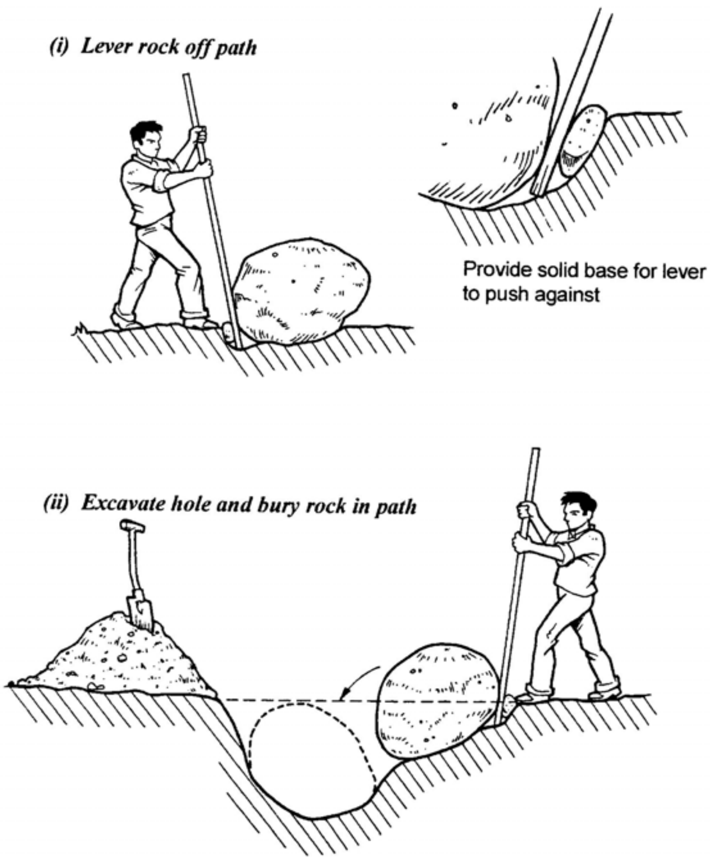
3.1.1 CLEARING AND GRUBBING

Mark the route with pegs or posts and clear the width needed for the path and drains. This may involved removal of bush, trees, roots and rocks.

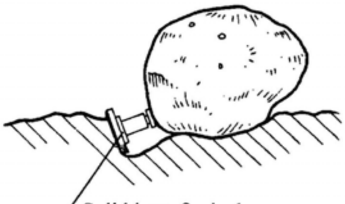
The removal of large rocks or boulders can be a particular problem. A number of methods are shown in the following sketches.

Great care is needed to avoid accidents. The work should be carried out by experienced workers. Proper tools which are strong enough for the work must be used.

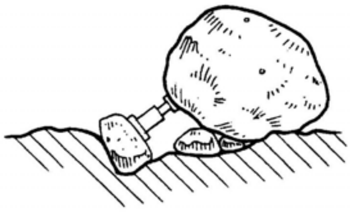
Figure 3.1: Clearing of Rocks and Boulders: Methods in Order of Ease



(iii) Use lorry jacks to move rock

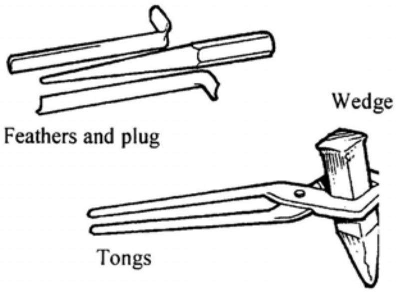


Solid base for jack

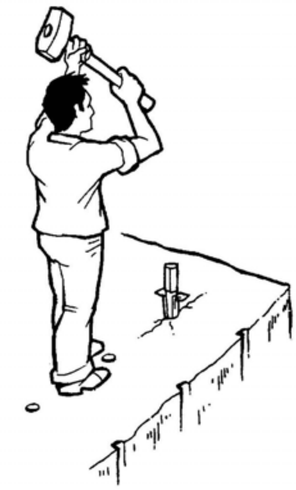


Use wedge to prevent rock rolling backwards and re-position jack

(iv) Split rocks with hammer and splitting tools



ROCK SPLITTING TOOLS



1. Use existing cracks and faults to help splitting using wedges/chisels
2. If this does not work make holes in rock and hammer plug into feathers. A number of holes may be used to split along a line.

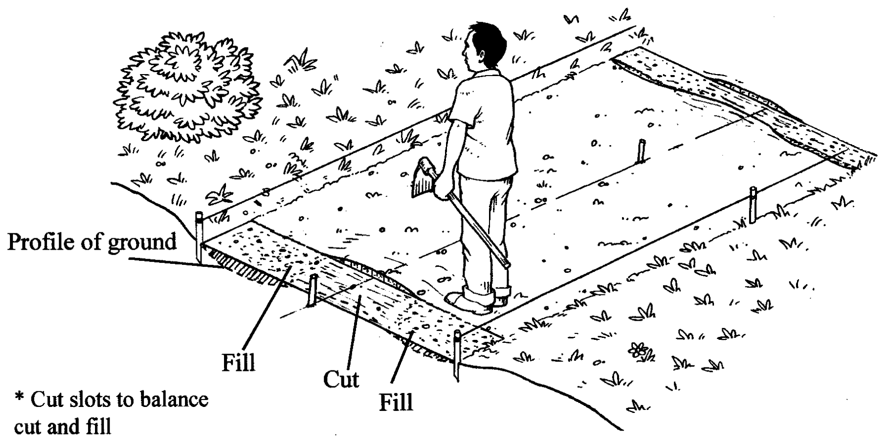
(v) Use fire and water

- Build fire around rock and heat for at least 6 hours
- Pour cold water over rock. Rapid cooling of outside of rock should cause it to split

SETTING OUT AND CONSTRUCTION

The steps in setting out and constructing a new length of path have been described in Section 2.2.5. This section reinforces the two main stages in achieving a good quality path and presents designs of paths for various conditions.

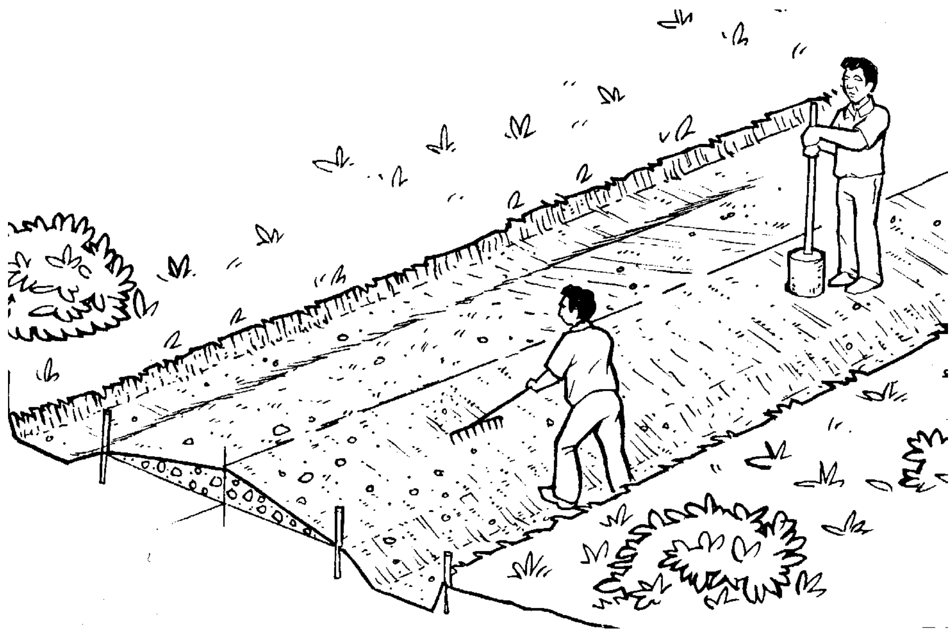
Figure 3.2: Construction on Flat and Rolling Terrain



Stage 1: ***Prepare a level bed for forming the path.***

1.1 Measure out and clear the formation width (path and drains) of the path.

1.2 Cut slots every 5 to 10m to provide a guide for excavation to level.



Stage 2: ***Excavate the drains and form the profile of the path.***

2.1 Excavate drain ditch, spread and compact the soil to form the 'plug'.

2.2 Cut side slopes of the drains; use a profile board to get the correct shape.

2.3 Spread and rake soil to form camber, use camber profile board to get correct slope of 8%. Compact the soil to form the surface of the path. **It is essential to achieve good compaction at all stages to avoid damage and depression of the path surface.*

Figure 3.3: Design of Path for Flat Terrain

The sketches below show the standard design of path for flat terrain. The profile of the camber and drains should be checked with profile boards shown below.

It is important that side drains have a fall along their length of at least 2% to allow water to drain away efficiently.

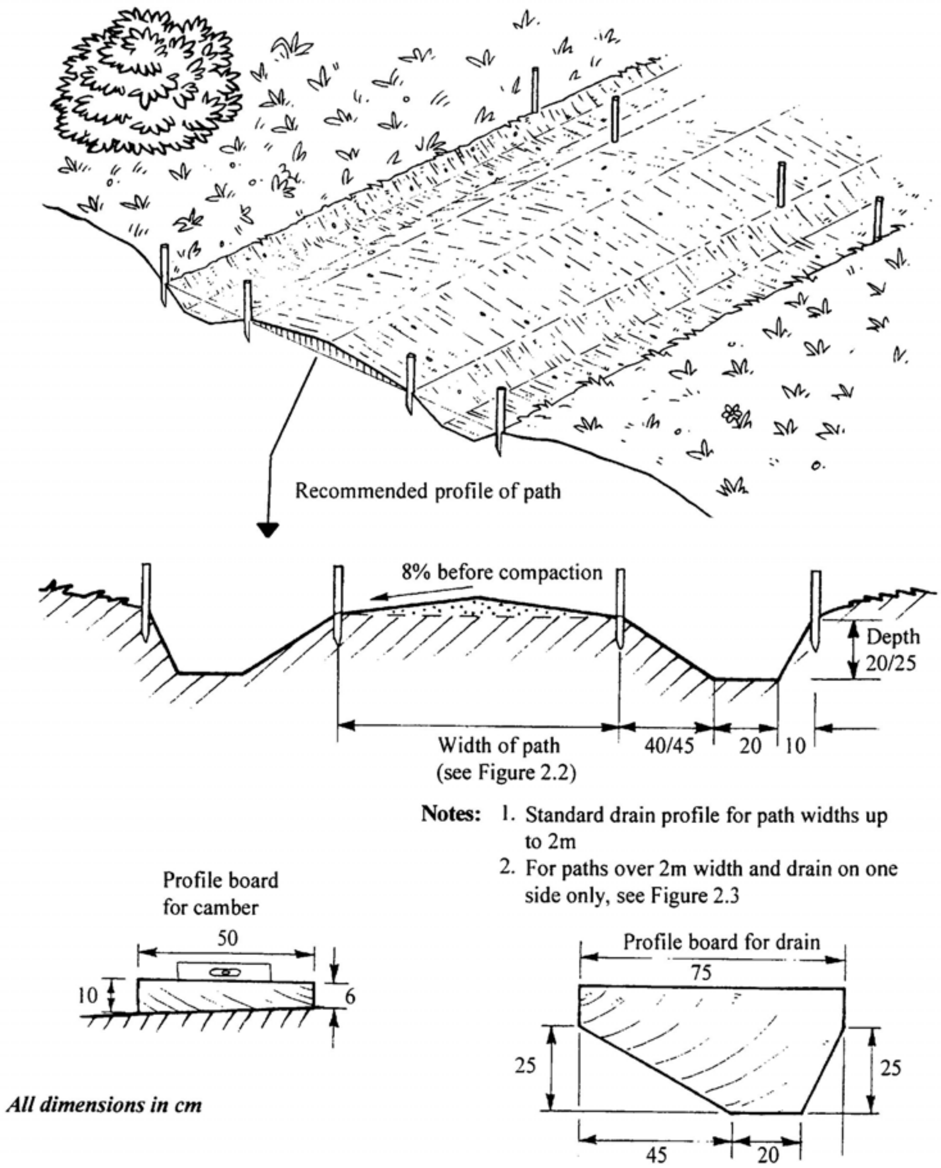
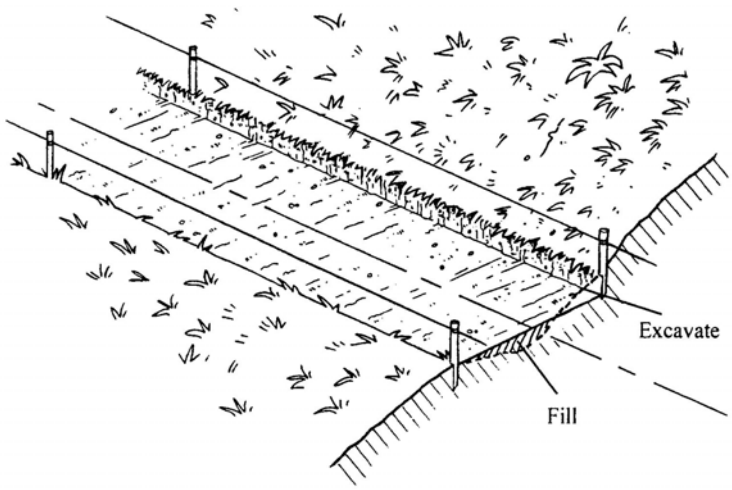


Figure 3.4: Setting Out on Side Sloping Ground

Step 1: Place pegs on path centre line every 5-10m

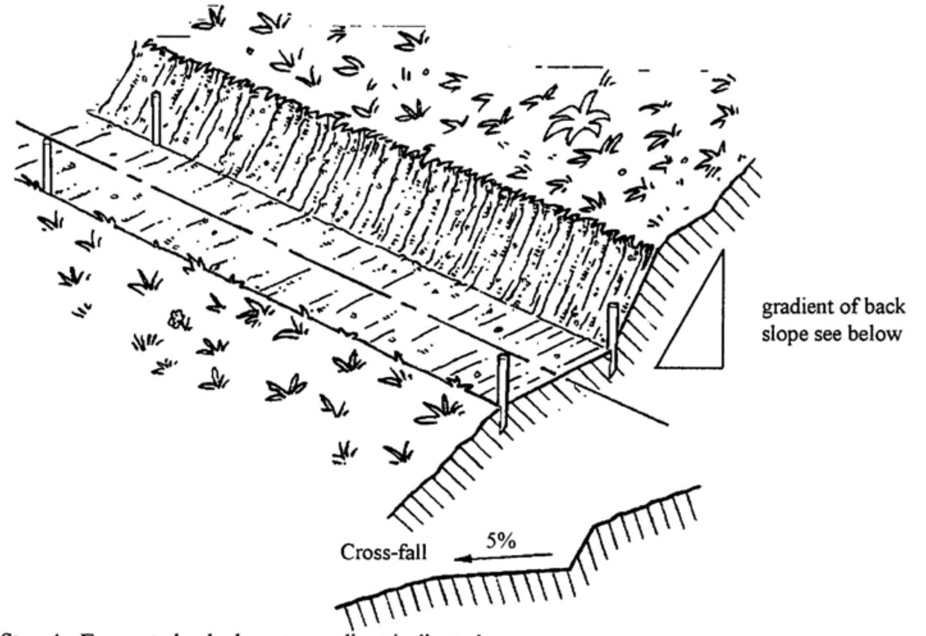
Step 2: Place a peg on each side of the path



Step 3: Excavate the ground between the pegs to the required cross-fall (see Figure 3.5)

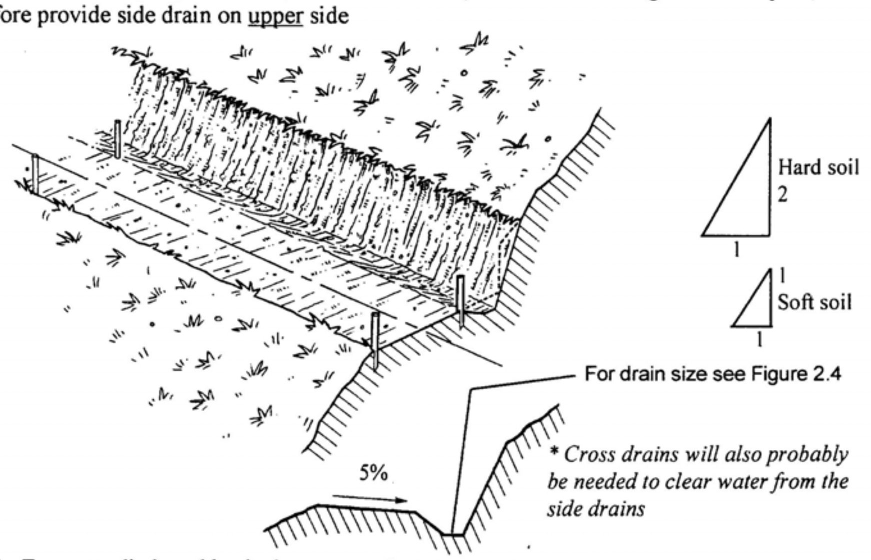
Figure 3.5: Design of Path for Side Sloping Ground

(i) On Gently Sloping Ground (less than 8%): Drainage across path



Step 4: Excavate back slope to gradient indicated

(ii) On Steeply Sloping Ground (Greater than 8%): Water flow too great across path, therefore provide side drain on <u>upper</u> side



Step 4: Excavate ditch and back slope to gradient indicated

3.2 IMPROVING PATH SURFACE

Paths can normally be constructed from the existing soil along the path. However, some ground or soil types are not suitable for path construction due to their drainage or erosion characteristics.

If the existing material is poor quality it will be necessary to replace it with an imported material with better characteristics. Spot improvements may be made to stabilise paths where there are isolated patches of poor material. Alternatively replacement materials may be required over long sections if the local soil is not suitable for path construction.

Areas that may require replacement material include:

- Very rough terrain
- Areas with sharp rough rocks
- Very loose sandy soils
- Easily erodible soils on steep slopes
- Black cotton soil
- Wet marshy areas

Improving Surface Layer of Path

In some cases it may be sufficient to mix an imported material with the surface material to improve the surface layer. For Example:

- Sand mixed into a clay surface can reduce the slipperiness of the clay when wet.

- Mixing clay with sand can bind the sand into a more stable surface

Note: These techniques will only work if the base material below the surface is strong/rigid enough to support the surface layer and prevent it from breaking up and/or sinking.

Replacement of Path Material

Four options are shown in Figure 3.6. Important features are:

- Keep the area treated as small as possible - Spot improvements will often be effective

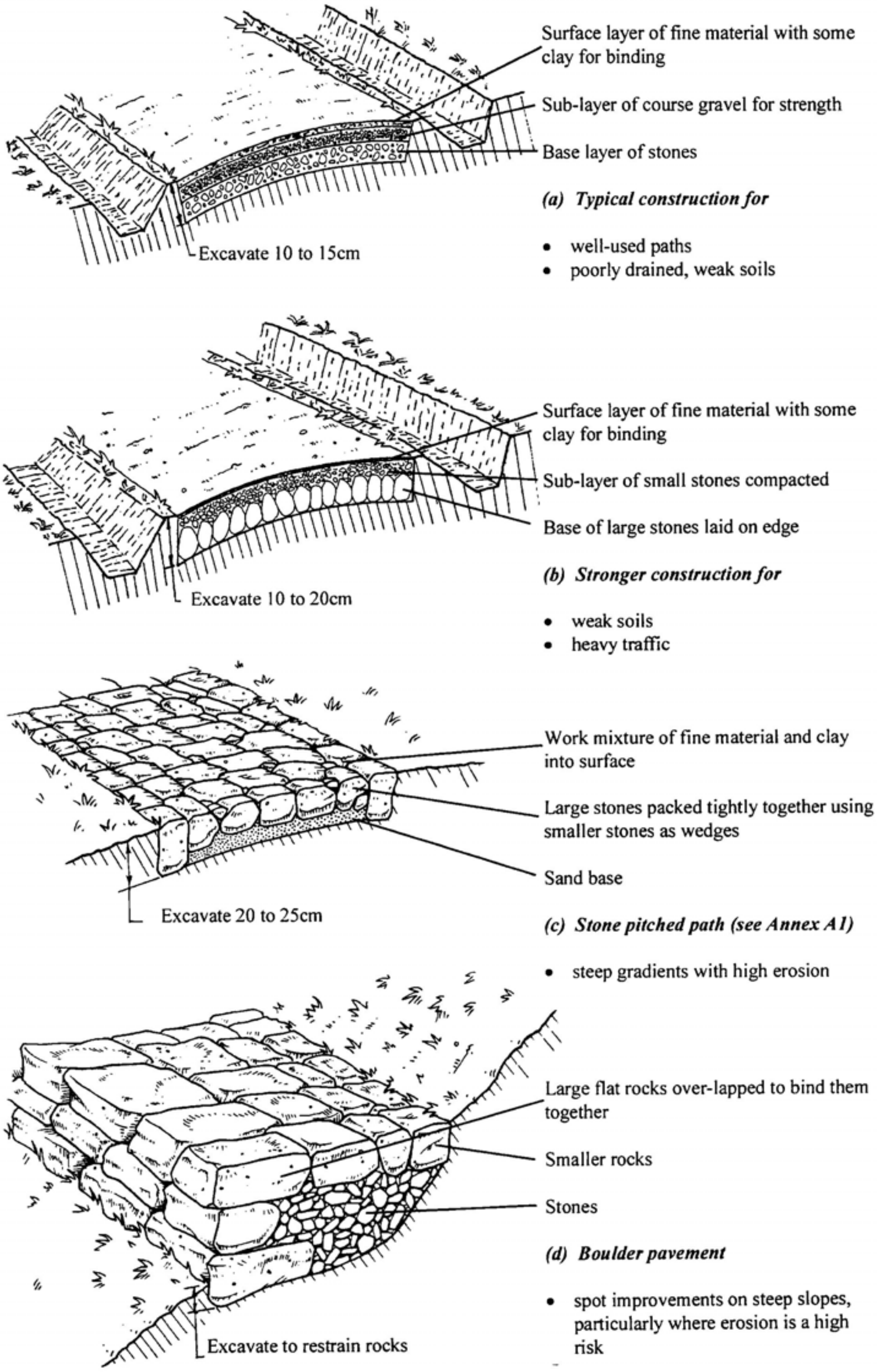
- Excavate the areas to the depth indicated in the Figure

- It is essential to achieve a strong and stable base layer to support the improved surface

- The surface must suit the traffic using the path. For example, if bicycles or walkers without shoes use the path a smooth, firm surface will be needed

- These techniques can only be used in locations where it is possible to transport suitable materials from nearby sources

Figure 3.6: Methods for Improving Path Surface



3.3 DRAINAGE

Lack of drainage is the cause of most problems associated with footpaths. A poorly drained path allows water to collect causing local flooding or areas of mud which are difficult or impossible to cross.

For most unimproved paths nothing has been done to control the flow of water or improve drainage. Uncontrolled flow of rainwater can cause erosion to the path surrounds, depositing debris and silt on the path. It can also cut channels in the path and wash away the path material.

The primary aims of good drainage are therefore:

1. To prevent rainwater collecting on the path

2. To control the flow of rain water on and around the path to avoid erosion damage to the path and surrounds.

This section provides guidelines on standard drainage methods for achieving these aims.

However, the most important factor in providing or improving drainage is to understand the behaviour of the rainwater and what is causing the problem. It is essential to obtain information from the local community and wherever possible to observe the problems first hand.

REMEMBER!

- Understanding the flow of the rainwater helps you to design an effective drainage system

Methods Covered in This Section:

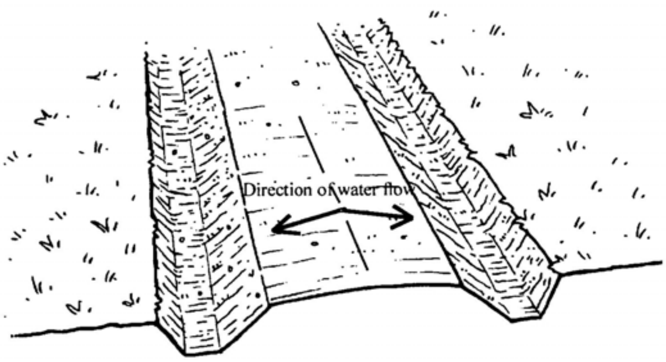
- *3.2.1 Path Surface* - camber or cross-fall to drain water off path
- *3.3.2 Side Drains* - remove water drained off path and edges
- *3.3.3 Turn-Out Drains* - carry water away from side drains
- *3.3.4 Catch-Water Drains* - prevent water running down hillsides onto the path
- *3.3.5 Scour-Checks* - control flow of water in drains to reduce erosion
- *3.3.6 Water-Cut Offs* - prevent water running *along* path causing erosion
- *3.3.7 Stone-Lined Drains* - for steep slopes and high run-off where erosion of drains is a problem.

3.3.1 DRAINAGE OF PATH SURFACE

The surface of the path should not be flat, but should have a small cross- slope on it to encourage water to flow off the path. The direction of slope will depend on the ground conditions. A slope of 5 to 6% is needed (1 in 20 to 1 in 16) for cambers and cross-falls.

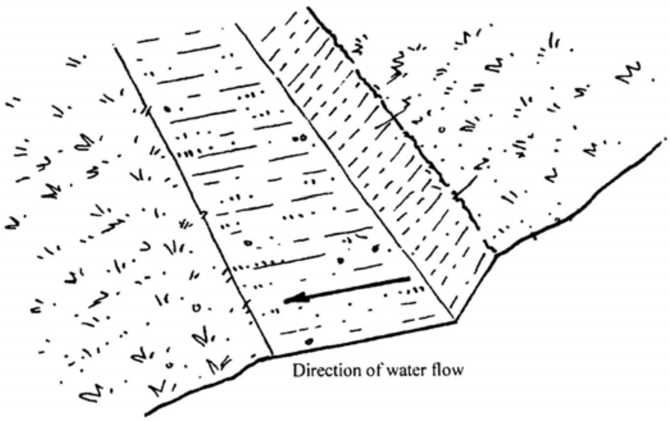
If the slope **along** the path is greater than about 4% (1 in 25) cut-offs may be needed to prevent too much water flowing along the path (Section 3.3.6).

Figure 3.7: Paths on Flat Ground, Gently Rolling Terrain or Following a Ridge



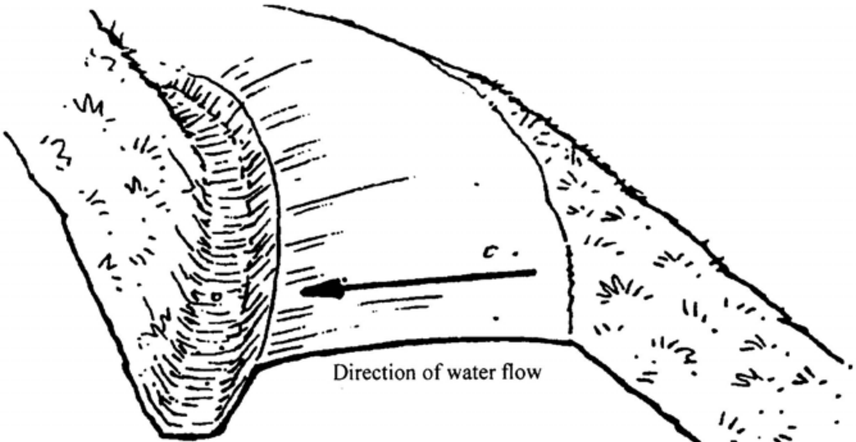
A camber on the path is the most appropriate for these paths. *Side drains* are required on both sides to collect water from the path and surrounding terrain. This water should then be diverted away from the path through *turnout drains*.

Figure 3.8: Paths on Gentle Slopes with Permeable Soils and Low Run-Off



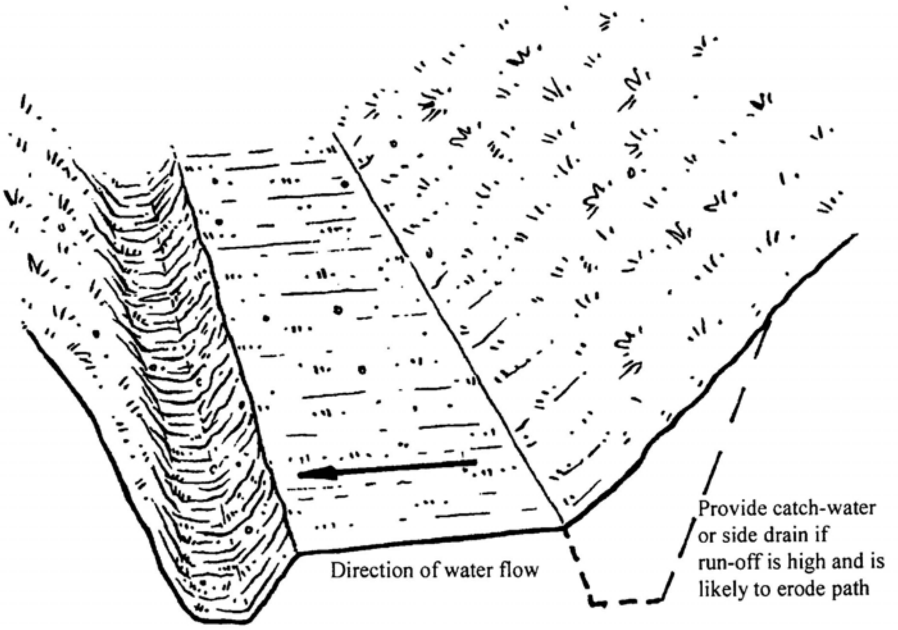
-
Out-sloping crossfall is suitable for these paths.
- A side drain is not needed if water flows away from the path unaided.
- As slope or run-off increases a *catch water drain* should be provided on the up-hill side of the path (see section 3.3.4)

Figure 3.9: Paths on Steep Slopes with High Run-Off



- This may be used where a catch-water drain is not feasible. A side drain will be required on the uphill side of the path - Cross drainage is needed at regular intervals to pass water from the side drain across the path

Figure 3.10: Paths Passing Through Gulleys



- This has to deal with water run-off from both sides of the path.
- If run-off is high on both sides then side drains will be needed on both sides of the path.

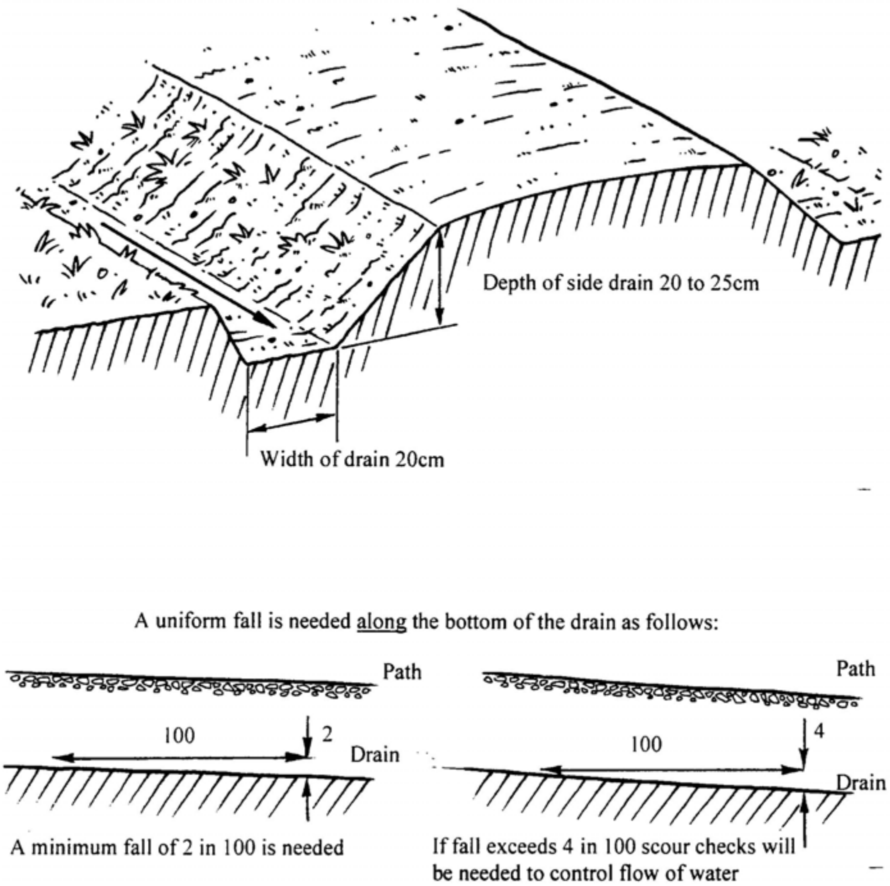
3.3.2 SIDE DRAINS

Side drains should be constructed along the sides of paths on flat or rolling ground and on sloping ground where water does not naturally drain away from the path.

They collect surface and sub-surface water flow and carry it away from the path preventing the paths themselves becoming water logged.

The shape and minimum dimensions of side drains are shown in Figure 3.3. The cross-section should be larger where run-off is particularly high.

Figure 3.11: Details of Side Drains



Side drains must be constructed to allow water to flow smoothly along the drain without too much speed which can result in erosion of the drain.

3.3.3 TURNOUT OR MITRE DRAINS

Turnout drains lead water from the side drains away from the path or track. The construction of Turnout Drains should follow the same rules as Side Drains.

The angle that the turnout drain makes with the side drain is important. The best angle is 30° (10 : 17) but the angle should never be more than 45° (10 : 10).

The spacing between turnout drains is also important to control the amount of water flowing in the side drain and therefore erosion of the drain.

The maximum spacing depends on the longitudinal slope of the side drain and the type of soil. Guidelines are given in the table below.

Guideline on Maximum Spacing Between Turnout (Mitre) Drains for Normal Soils

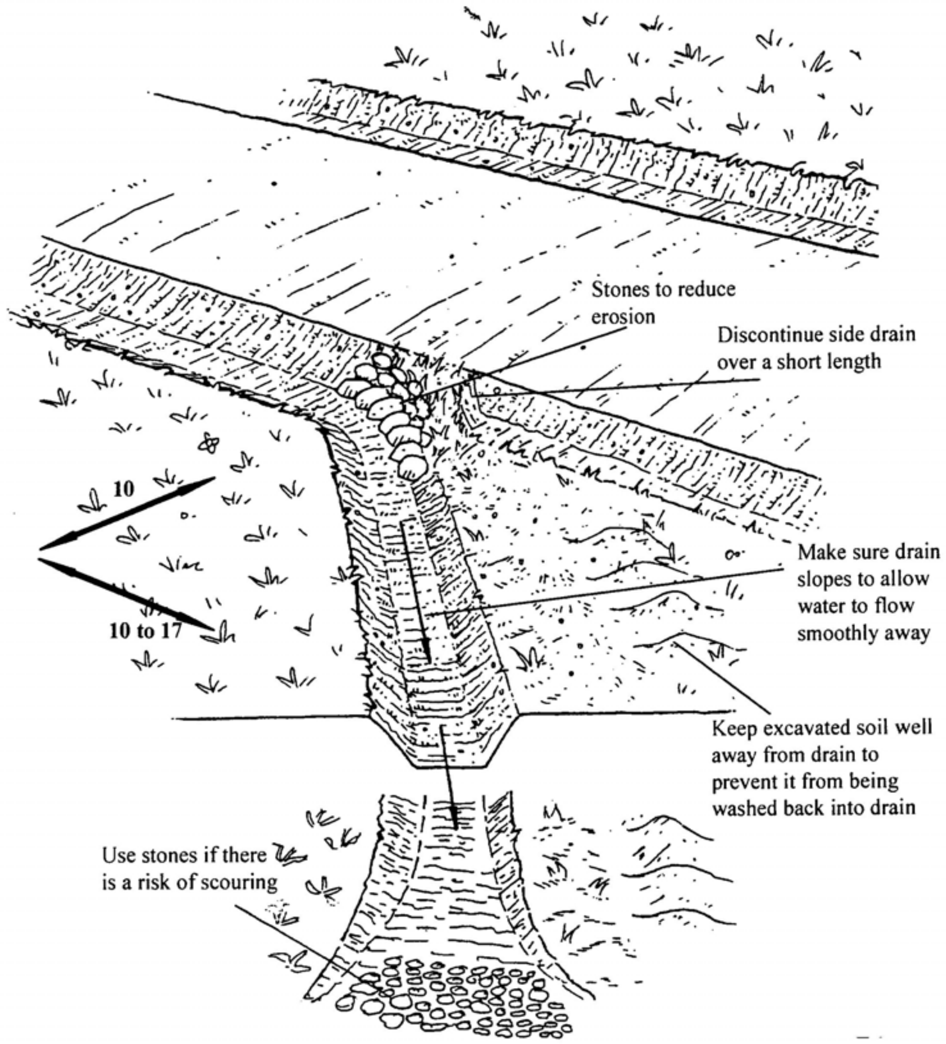
Slope of side drain	2% (1)	4%	8%	12%
Spacing (m) (2)	100	150	100	50
Main design factor	Silting	Erosion/Scouring		

Notes: 1. Slopes along drains of less than 2% should be avoided if possible because of silting. If this is not possible, spacing should be reduced to about 50m at 1% slope.

2. Spacing on soft soils should be reduced by up to 50% (half). On gravel or stone spacing may be increased by up to 50%.

3. Mitre drains will also be needed at dips in the path where the slope changes from downhill to uphill.

Figure 3.12: Turnout or Mitre Drain



Outlets:

- Locate outlet where outflow can naturally drain away
- Carefully locate to avoid damage to cultivated land and vegetation. For example locate at the boundary between fields
- Open up the drain at the outlet to spread flow
- Use stones and rocks if the outflow is likely to cause scouring

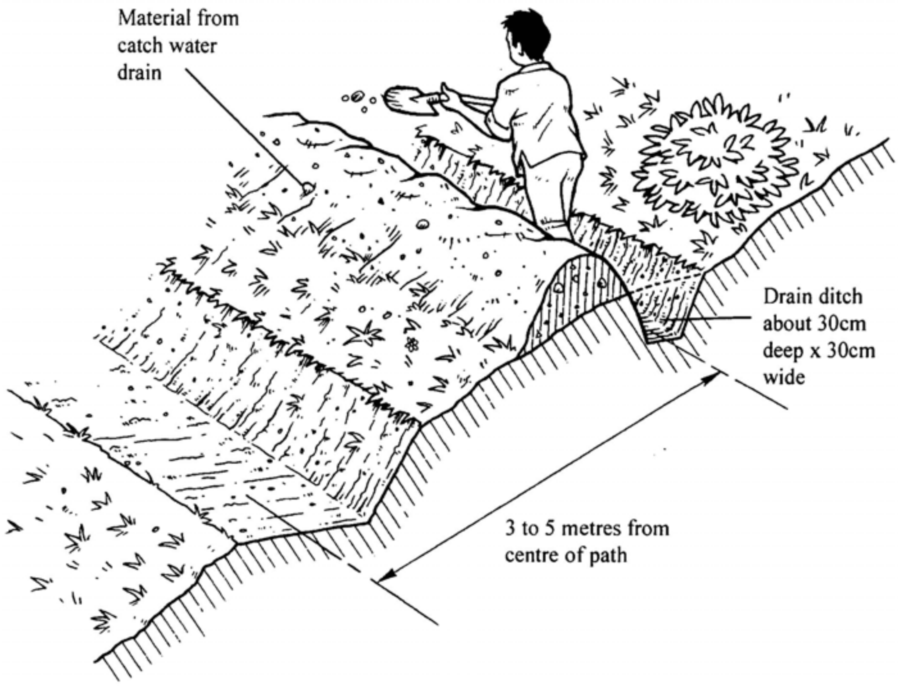
3.3.4 CATCH WATER DRAIN

Catch water drains are required for paths on a hillside where there is a considerable flow of water down the hill towards the path. The catch water drain prevents the water flowing onto the path.

A catch water drain is a ditch about 30cm deep by 30cm wide (at the bottom), constructed on the uphill side at a distance of 3 to 5m, from the centre of the path. The soil excavated from the ditch can be placed to form a small bank on the lower side of the ditch.

The drain should follow the contour of the hill to give a slope along the drain of 2 to 4%. A higher slope will need *scour checks* to control the water flow.

Figure 3.13: Construction of Catch Water Drain

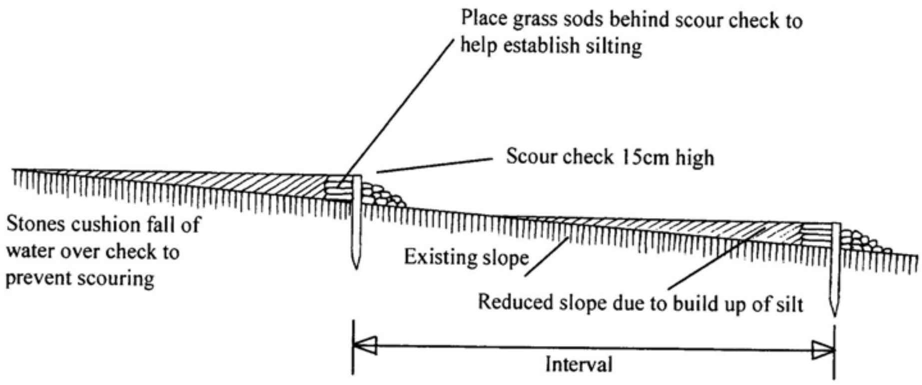


If the catch water drain is long, *turnout-out* (mitre) drains may be needed to prevent overflow. These should be directed away from the path if the slope allows this. If not, the turn out drain should lead into a *cross drain* (Section 3.6.1) or *culvert* (Section 3.6.2) to take water across the path.

3.3.5 SCOUR CHECKS

If the slope of drains is greater than about 4% (1 in 25), the surface of the drain is likely to be eroded (scoured) by the fast flow of the water. In this case *scour checks* should be used. These comprise small structures (checks) built within the drain that slow the flow rate of water by reducing the gradient of the side ditch due to silt building up behind the structure.

Scour checks can be built from either sticks or pebbles. The action of the scour check is shown in the sketch below.



Interval

The distance between scour checks should reduce the effective slope of the drain to about 4% as follows:

- about 20m at a drain slope of 5% (1 in 20)
- to about 6m at a drain slope of 10% (1 in 10)

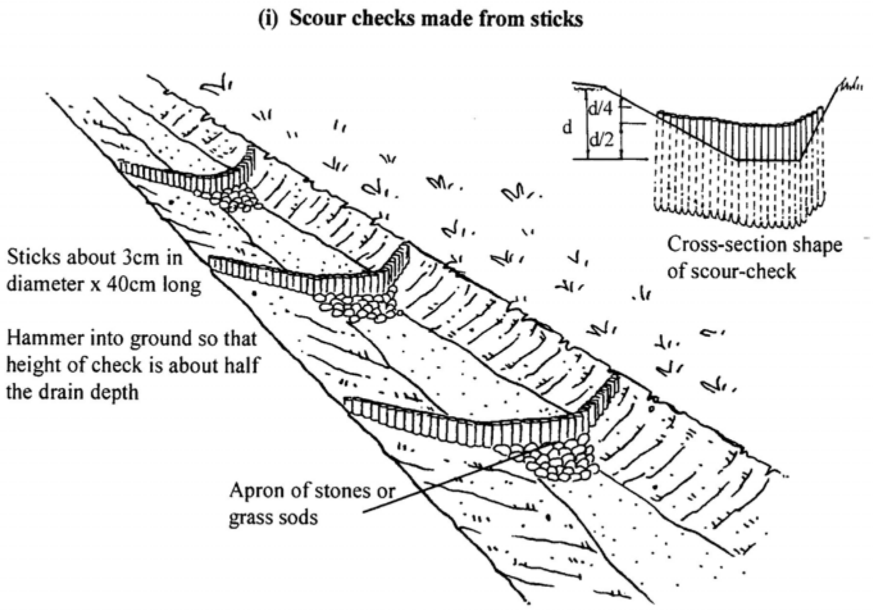
Note: The scour check should be shaped to reduce flow rate BUT not to block the drain.

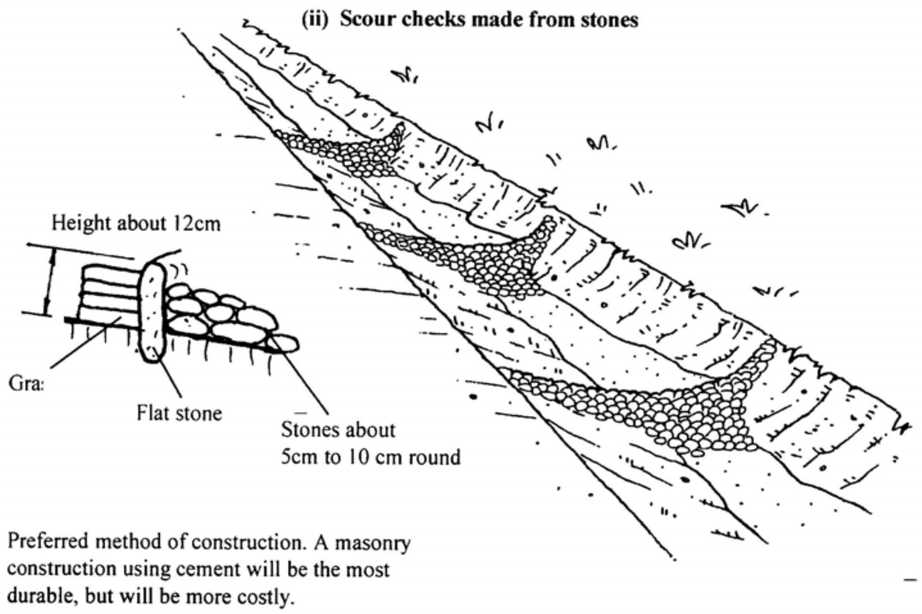
Natural Checks

Erosion of drains can also be reduced by natural means, by allowing grass and other vegetation to grow in the drains. This can also reduce silting. This is a technique which should be encouraged, but it needs regular maintenance to cut the grass to prevent drains from becoming blocked.

Natural checks of suitable plants can be planted at appropriate intervals (similar to distances between scour-checks) to reduce flow rates where required.

Figure 3.14: Construction of Scour Checks





3.3.6 WATER CUT OFFS

As the slope *along* the path increases there will be greater flow of run-off water along the path which can cause erosion, particularly in softer soils.

For slopes above 3%, *water cut-offs* should be used to divert the run-off to the side of the path.

The spacing of cut-offs depends on the path soil and slope. General guidelines are given in the following table[1]

Recommended Spacing of Water Cut-Offs (m)						
Type of Soil	**Longitudinal Gradient in %**					
	2	**4**	**6**	**8**	**10**	**12**
Loam	100	50	30	20	15	*
Clay-sand	150	100	60	50	30	15
Clay or clay-gravel	-	150	90	60	50	30
Gravel/rocky	-	-	230	150	100	80

* Gradient not recommended in this type of soil
- Water-bar not usually required

Water cut-offs should be particularly located where there are signs of significant erosion, such as channels cut in the path, and patches of debris.

The cut-off should lead into a *turn- off drain* to take the run-off well away from the path.

If there is no cross-fall on the sides of the path to permit water to drain away naturally then *side drains* should be used to carry run-off further along to where it can be drained away.

Two basic types of cut-offs are described in this section.

(i) Drainage Dip

(ii) Water Bars

1. Source: Design and Appraisal of Rural Transport Infrastructure,. Jerry Lebo and Dieter Schelling; World Bank Technical Paper No. 496, Washington, April 2001.

(i) Drainage Dip

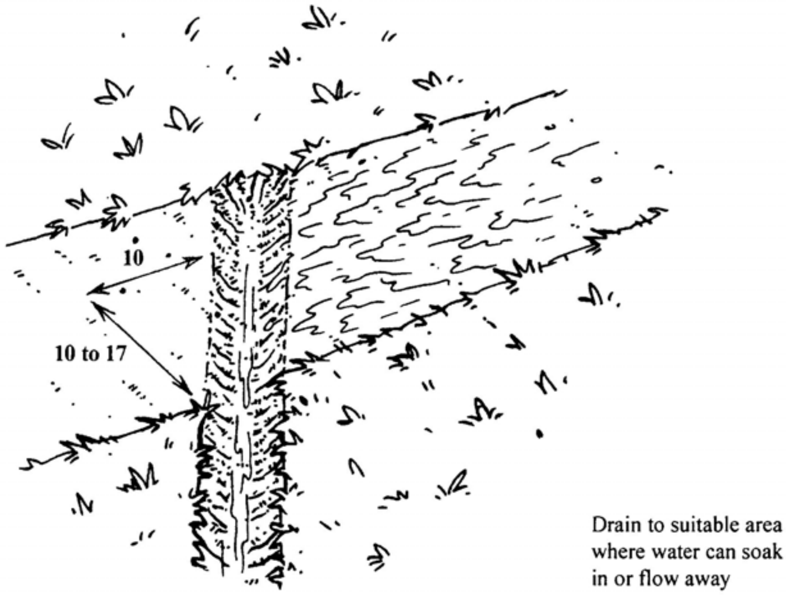
A drainage dip is the simplest and cheapest type of water cut off, and should always be considered as the first option.

It consists of a cross-drain excavated at an angle of 45 to 60 degrees to the direction of the path which diverts the water away to the downhill side of the path.

Drainage dips can be used on gentle slopes where the soil is stable and firm. Stones can be used to prevent erosion in the dip if they are available.

Drainage dips are not suitable if wheeled vehicles use the path.

Figure 3.15: Drainage Dip



Drainage dip cut at angle across path intercepts flow of water <u>along</u> path

(ii) Water-Bars

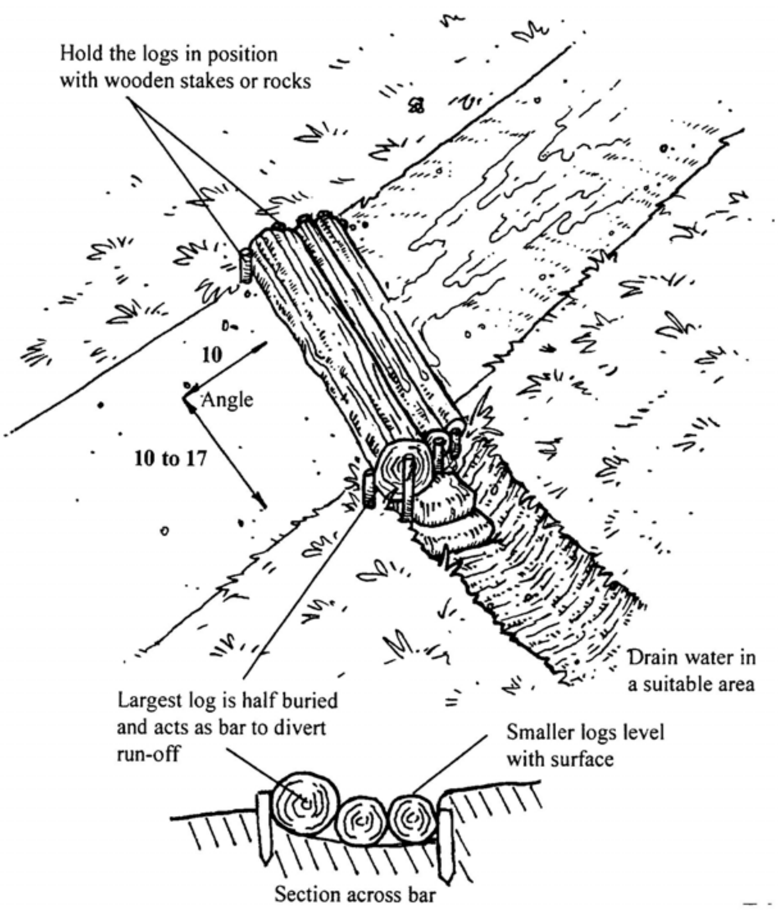
A water-bar is an obstruction placed at an angle of 45 to 60 degrees to the direction of the path to lead water running on the path away to the downhill side. The obstruction can be constructed from logs or stones depending on what is available.

- ***Water-bars made from logs***

These comprise 3 logs set in a trench excavated across the path at an angle. The logs should be 10 to 15cm in diameter and extend about 20cm each side of the path. Light wheeled vehicles are able to run over the logs.

The logs should be held in place by wooden stakes, about 5cm in diameter and 40cm long.

Figure 3.16: Log Water-Bar



Rock Water-Bar

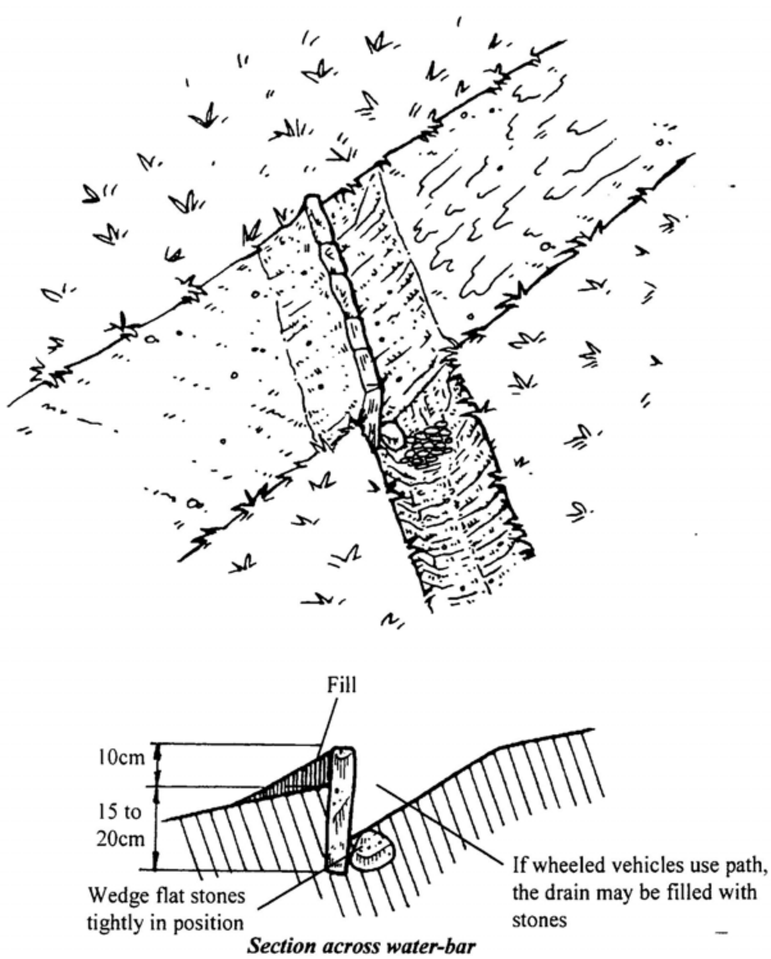
If large flat stones/rocks are available then these may be used instead of logs to provide a longer lasting water cut-off. They are not suitable for wheeled vehicles unless the drain is filled with stones. However, this reduces the rate of run-off.

Stones should be at least 25cm deep and 4cm thick, larger stones are better. Set stones in a trench excavated at an angle of 45 to 60 degrees to the direction of the path, with about 10cm raised above the surface of the path as a barrier.

One row of stones may be adequate, particularly for thicker stones, but edges which are wedged together may need to be trimmed to minimise gaps and water leakage.

Two rows of stones, overlapped to prevent water leakage, are better.

Figure 3.17: Rock Water-Bar



3.3.6 STONE LINED DRAINS

Stone lined drains are used to overcome problems of excessive erosion of earth drains. They tend to be used mainly in hilly areas with high rainfall and run-off.

Although construction involves substantially more time and effort in collecting and placing the stones, stone-lined drains require less maintenance.

More detailed information on stone-lined drains is provided in the annex on stone paths, Annex A.1.

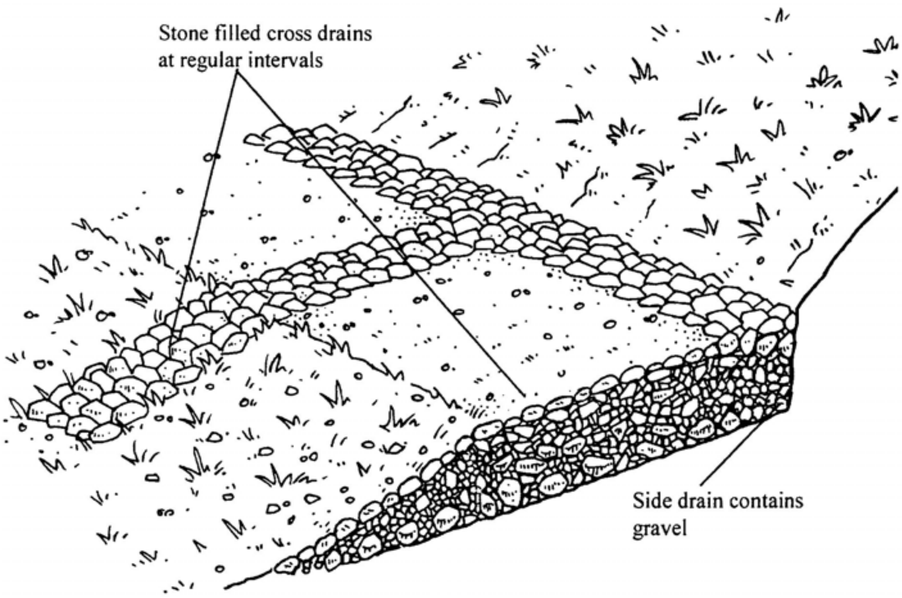
French Drains

Although these resist erosion and are used on hillsides, they are less useful for high run-off than lined drains because of their reduced flow capacity.

However, they are useful for other situations:

- *Low maintenance drains* – the stones limit growth of vegetation so French drains may be used in situations where maintenance is particularly difficult.
- *Cross drains* or *water-bars* on paths where wheeled vehicles use the path
- *Intercepting sub-surface flow* – can be used to intercept sub-surface flow of water which is seeping onto the path.

Figure 3.18: French Drain



Lined Ditches

In hilly areas with a high rainfall, large amounts of water may flow down the path drains. This water can cause severe erosion of the drain. In areas where erosion is excessive it will be necessary to line the ditch. This may be done by using flat stone slabs or smaller stones held in place with mortar.

Figure 3.19: (i) Ditch Lined with Stone Slabs

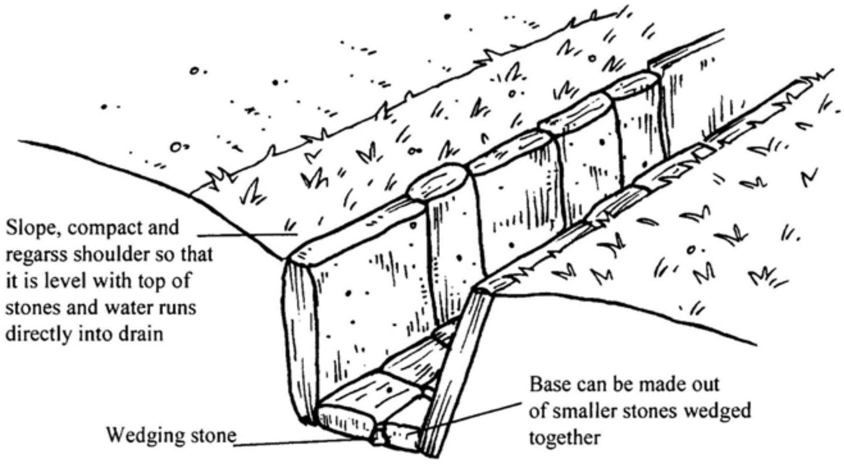
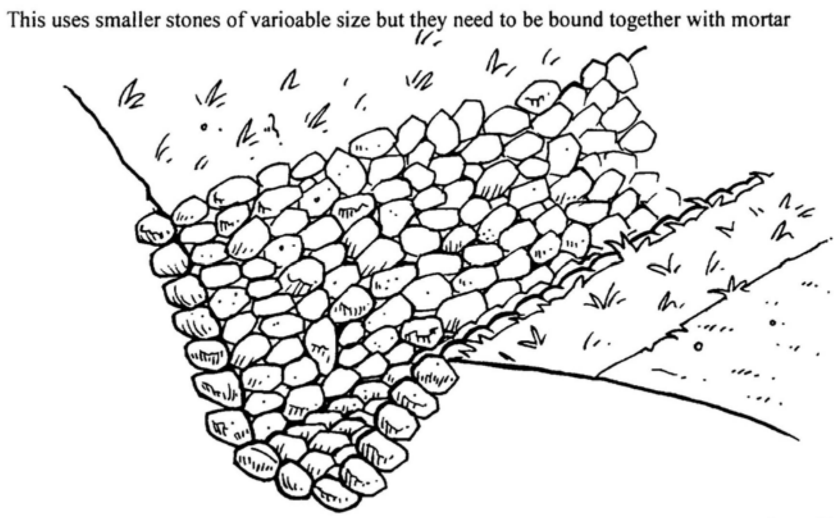


Figure 3.19: (ii) Ditch Lined with Stone Slabs



3.4 PATHS ON STEEP SLOPES

Obviously it is best to try to avoid hills but often paths have to pass over hills so that travellers have to climb or descend slopes. This causes difficulty due to extra effort needed and keeping a grip on the path to control movement. Slopes which are too steep can be dangerous for the traveller.

The table below lists the maximum slopes recommended for different footpath users – for example if animal- drawn carts are to use the path the slope should not exceed 8%.

For slopes greater than 12% it is only really feasible for walkers, possibly pushing a bicycle or wheelbarrow, and pack animals to use the path.

As slopes approach 25% even walking becomes difficult and steps are needed.

User	**Desirable maximum gradient**	
Bicycle with Trailer	5%	1 in 20
Bicycle	7%	1 in 14
Animal-drawn carts	8%	1 in 12
Loaded porters	10%	1 in 10
Pedestrians	12%	1 in 8
Pack animals	12%	1 in 8
Shallow steps required	25%	1 in 4
Moderate steps required	33%	1 in 3
Steep steps required	50%	1 in 2
Hands needed to aid ascent	70%	1 in 1.4

The *desirable maximum gradient* is the steepest gradient that can be negotiated without excessive effort by the particular user.

3.4.1 METHODS FOR DEALING WITH STEEP SLOPES

If the maximum recommended gradient will be exceeded when the path leads directly up the slope, the path may be aligned across the slope to reduce the gradient to an acceptable level.

If this is not feasible the following options are available

Methods for Dealing with Steep Slopes
• ***Cut and fill slopes to even out gradient:*** - This allows path to follow a direct route - <u>But</u> it involves substantial excavation work, often in stony soils ***Not Recommended***, although may be used to a limited extent for very short slopes
• ***Use of handrails of wooden poles or rope*** - allows path to follow direct route and requires little construction - <u>But</u> only suitable for walkers and may not be suitable for persons carrying heavy loads, or adequate on steep, slippery slopes ***Not recommended***, although may be used with steps
• ***Realignment of path into zig-zag form (see Section 3.4.2)*** - May be used by walkers, animals and wheeled vehicles - <u>But</u> increases length of path and therefore construction work substantially ***Recommended*** as only feasible method for a range of traffic. Compare with more direct route and steps if path is for walkers only
• ***Steps of various forms (see section 3.4.3)*** - Allow more direct, shorter route and may be the only feasible method in particularly steep areas - <u>But</u> involves considerable construction and regular maintenance. Only practical for walkers, although pushed bicycles and pack animals may be able to negotiate low steps with large platform areas. ***Recommended*** as shortest route when path is for walkers only

Summary:

- A zig-zag path is the only practical solution if the path has to cater for wheeled vehicles. If the path is only for walkers compare the work and resources needed with a more direct route using steps.
- A path with steps gives the most direct route for walkers but regular maintenance may be needed to keep the path in a safe condition.

3.4.2 ZIG-ZAG FOOTPATHS (HAIRPIN BENDS)

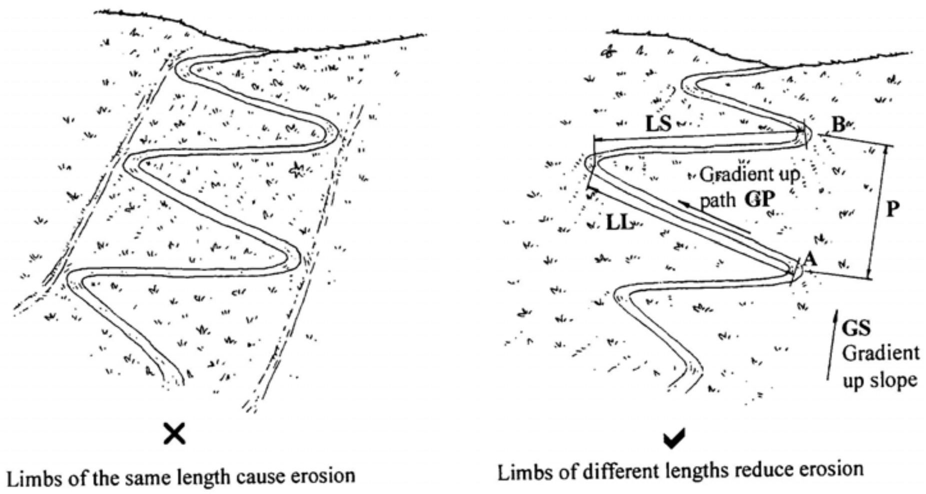
Zig-zag paths may be used on the sides of steep hills to keep the path gradient within acceptable limits. They "zig-zag" across the slope rather than directly up the slope

Design points:

- Avoid limbs of the same length otherwise water discharge from one hairpin may run onto the one below. Limbs of different length also discourage people to cut across from one bend to the next.

- The desirable minimum length of each limb should be 40m

Figure 3.20: Layout of Zig-Zag Paths



To layout the path the distance between hairpins 'P' may be found as follows:

Rise from A to B = P x gradient of slope = P x GS

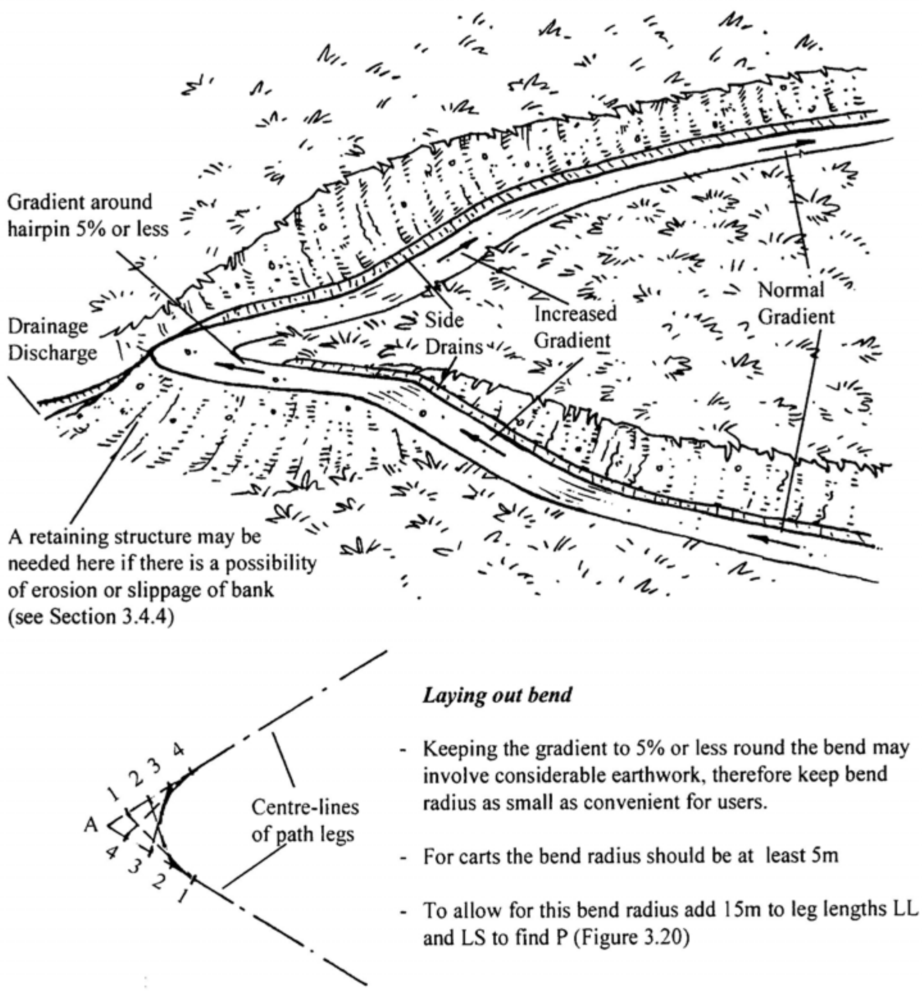
Gradient along path GP = Rise/leg length = P x GS/ (LL+LS)

$$\text{Therefore } P = \frac{GP}{GS} \times (LL + LS)$$

For example if the gradient of the slope is 1 in 6, the leg lengths LL = 50m, LS = 40m and the required path gradient is 1 in 10, then P = 6/10 x 90 = 54m. To allow for the bend, see Figure 3.21.

- As the hairpins are most susceptible to erosion they should be positioned on firm ground and avoid the use of fill material
- Gradient on the hairpin should be less than 5%
- Gradient on path before and after the hairpin should be steepened to discourage people cutting the corner at the end of each limb
- The desirable minimum length of each limb should be 40m.

Figure 3.21: Design of Hairpin Bend



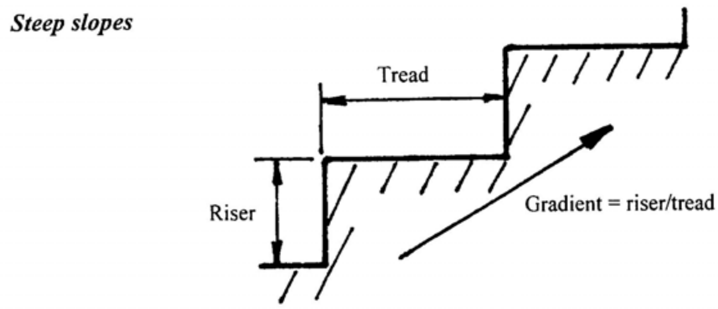
To set out bend:

1. Mark centre lines of path legs and point A.
2. Estimate where bend will start and mark points 1,2,3,4 at 2m intervals with pegs.
3. Join 1,1; 2,2, etc. with string to provide guide for centre line round bend.

3.4.3 STEPS

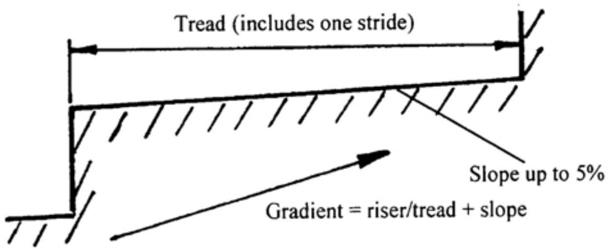
Steps should only be used for steep paths (gradients over about 25% - 1 in 4) as they will prevent the use of wheeled transport and inhibit the use of pack animals on the path. They can also require frequent maintenance.

Steps should be convenient to use, so the layout should match the average climbing and walking strides of users.The following rules should be followed:



1. Risers should never be above 25cm
2. Treads should be a minimum of 30cm
3. The best values are: riser = 17cm, tread = = 30cm which gives a gradient of 57%
4. The maximum practical gradient is about 67% - riser 20cm, tread 30 cm
5. If the gradient of the steps is greater than about 60% (1 in 1.7) a handrail should be provided for safety.
6. Steps should have a cross-fall of about 5% so that water drains to the side of the steps rather than down the steps.

Less steep slopes

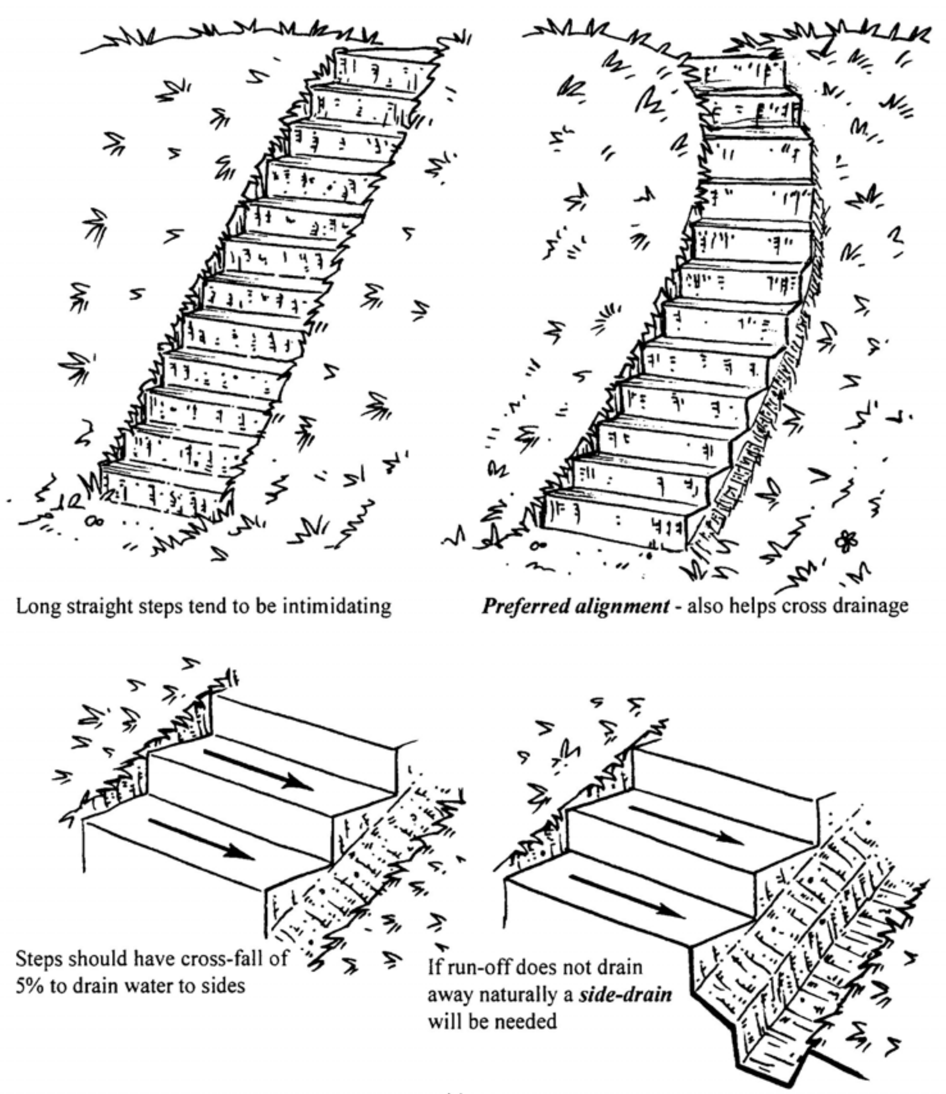


7. Where a shallow gradient is required the tread width should be increased by one stride (about 60cm). For example: riser 20cm + tread 30 + 60 = 90 cm and slope 3% gives a gradient of 25% (1 in 4).
8 Wider/longer treads may have a slope of up to about 5% as this reduces the number of steps needed. <u>However</u> the step must also have a cross-fall of about 5% to make sure water runs off to the side of the steps

General Guidelines for Design of Steps

- Construction of steps can require substantial work. Therefore choose the shortest route that minimises the work needed.
- However, long straight sections of steep steps can be intimidating to users. Therefore slightly curved routes are better for long, steep slopes – they also help with drainage.
- For lengthy, very steep slopes it may be necessary to provide zig-zag routes for steps to reduce the gradient and the effort for the user. In this case, provide obstructions to discourage users from taking short-cuts down the slope which may erode the slope
- It is important to provide effective drainage for steps. *Side drains, turn-off drains and scour checks may* be needed to achieve good drainage without causing erosion

Figure 3.22: Design Guidelines for Steps



Stone Steps

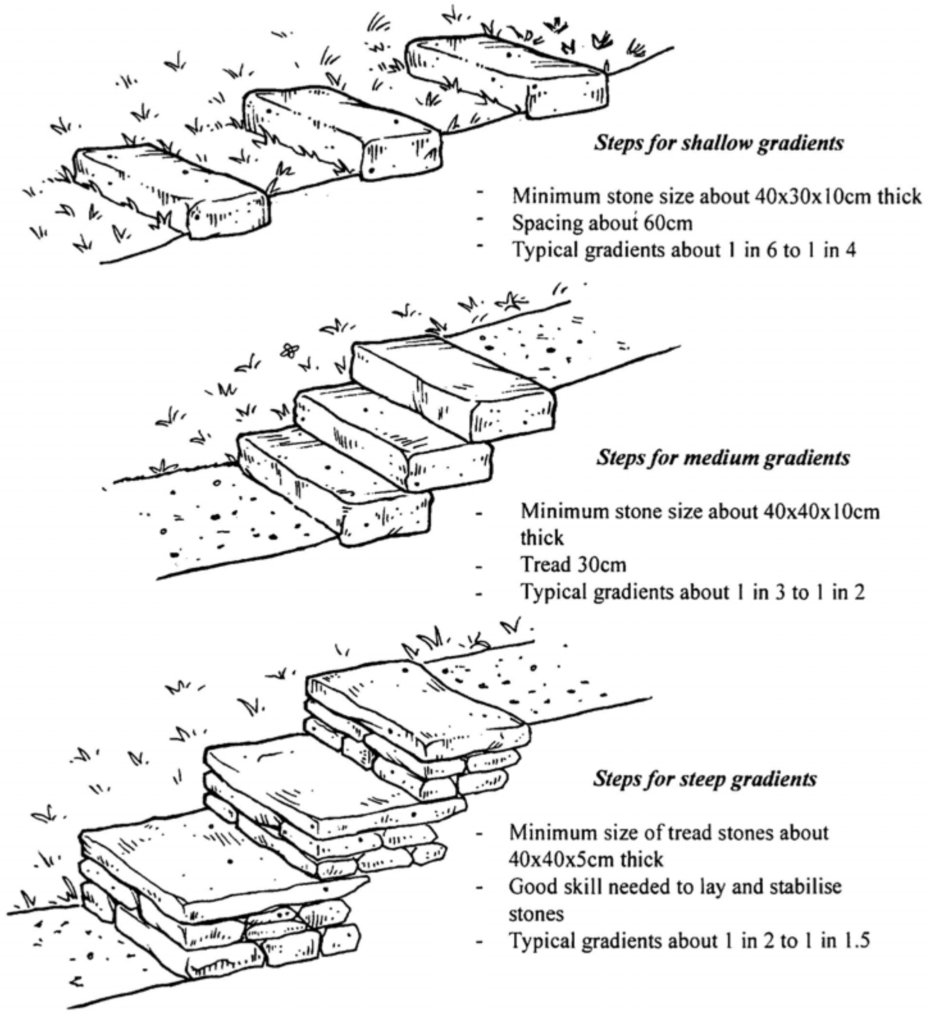
Stone steps have a longer life than other types and require less maintenance. However, they require availability of stones of appropriate shape and size.

Construction of stone steps requires good skill in laying the stones to make sure they are stable when walked on (do not move or rock) and properly sloped for drainage.

Three forms of steps are shown below made from large flattish stones. In all cases the design guidelines from Pages 3.30 and 3.31 should be followed.

Steps from smaller stones can be made, but these will need to be bound together with mortar.

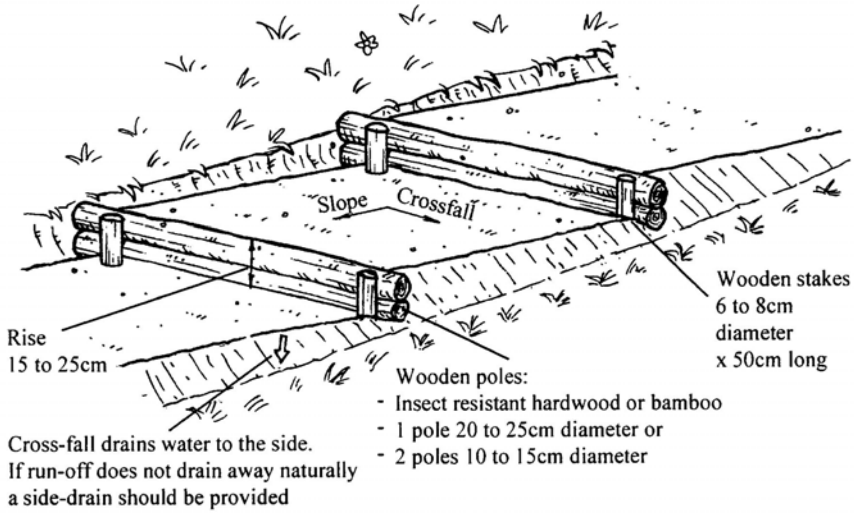
Figure 3.23: Stone Steps



Wooden Steps

Steps may be partly cut in soil and partly backfilled from excavation with the front edge supported by wooden logs. If the surface soil is not suitable, add a layer of suitable gravel mixture that is locally available. The design should follow the guidelines of pages 3.30/ 3.31.

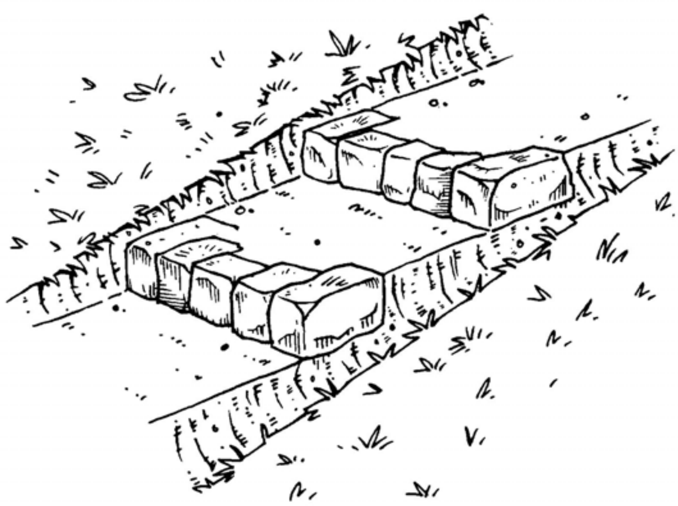
Figure 3.24: Wooden Steps



Stone Edged Steps

The wooden logs may be replaced with large stones if these are locally available. This provides a longer-lasting step.

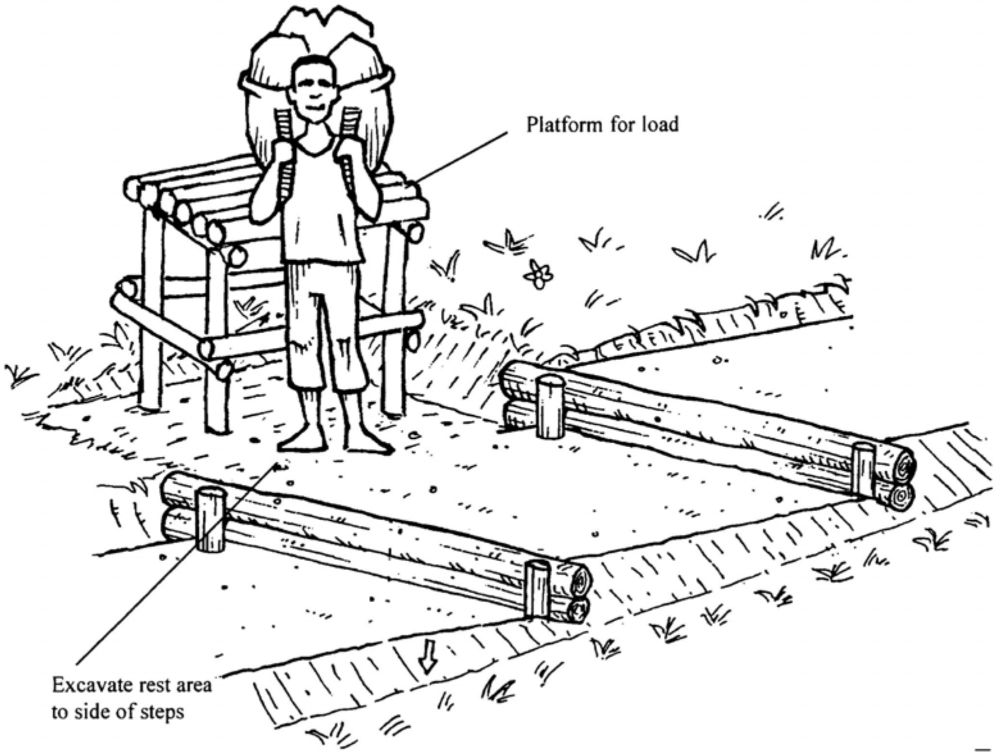
Figure 3.25: Stone Edged Steps



Rest Area

On long climbs, both with and without steps, it is a good idea to provide rest areas off the path or steps. These might be placed at 40 to 50m (or step) intervals. A rest area might also be located at the top of steep climbs. Rest areas should be provided with a platform on which loads can be easily set down and picked up by single persons without assistance. The height of the platform should be convenient for back loads. Persons carrying head loads can readily stoop to set down and pick up their loads. The Figure shows a simple platform made from logs which should be about 6 to 8cm in size.

Figure 3.26: Rest Area



3.4.4 RETAINING STRUCTURES

Paths on the sides of steep slopes must be designed to resist erosion. In the worst cases the design must allow for the possibility of landslides and collapse of the path.

Excavated embankments on the uphill side of the path and hairpin bends are common cases where there is a risk of landslides.

Where landslides have occurred, or there is a high risk that they will occur, some form of retaining structure is needed to hold back the soil and prevent the bank from collapsing.

The common method is to build a retaining wall. Two examples are shown in Figure 3.27 of dry walls (no mortar) using large stones.

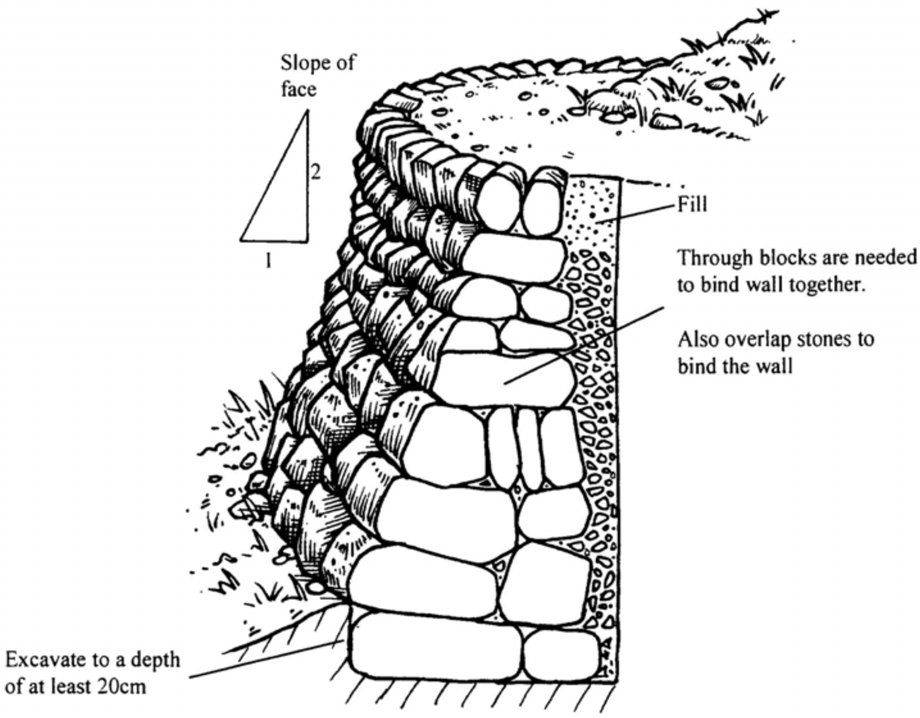
If only smaller stones are available then these need to be bound together with mortar. This will add a cost to building the wall.

If stones are not available, an option is to use wooden poles. However, these will have a limited life and will need to be replaced every few years.

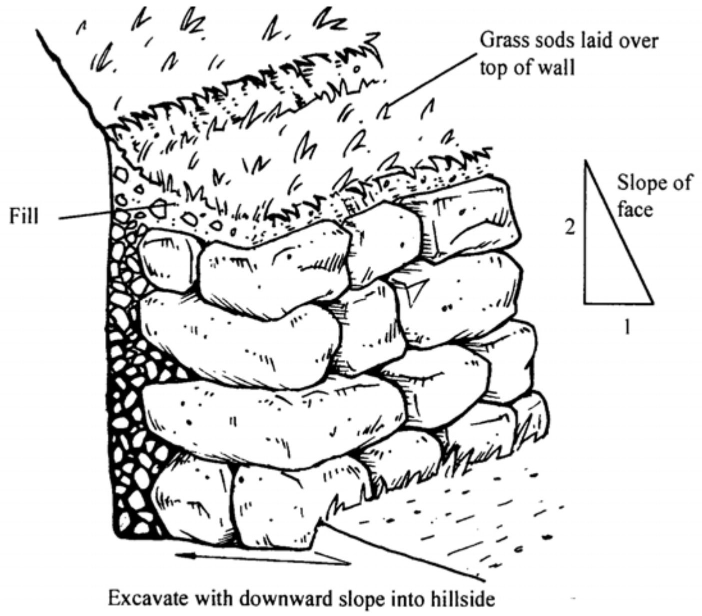
Figure 3.27: Retaining Structures

(i) Retaining Wall

This shows an example of a dry retaining wall used to support a hairpin bend

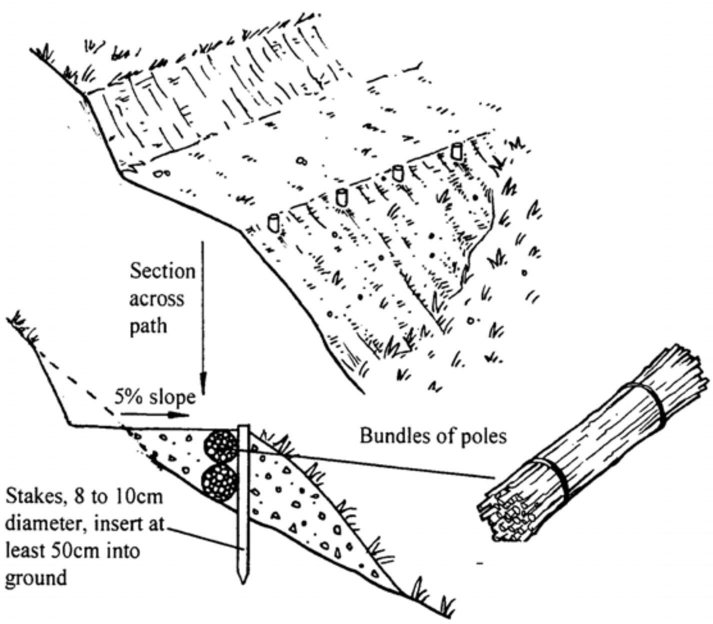


(ii) Retaining Wall Used to Support an Excavated Embankment on a Steep Slope



(iii) Retaining Structure made from Wood

This shows an example of a restraining structure made from bundles of wooden poles supported by wooden stakes. It is suitable for spot improvements on steep slopes.



3.5 MARSHY AND WET AREAS

Wherever possible footpaths should avoid crossing marshy and wet areas. However, if this is impossible there are a few methods which will provide reasonable access for most or all of the year.

The basic approach is to provide a foundation which can be supported by the soft marshy soil and raise the path above the surface of the marsh area.

Three common methods are outlined below.

Stepping Stones: this is the simplest and cheapest option but it is only suited to persons walking.

Large block-shaped stones are ideal. If these are not available a stone-box, sections of large tree trunks or sand-bags may be used.

This option is not suitable if the water level rises more than about 10cm in the rainy seasons.

Boardwalk: For less wet areas a simple and reasonably low-cost option for walkers is to use trimmed logs supported at each end on log-sills.

For more general traffic, sawn planks can be nailed on top of the logs. This introduces a significant extra cost.

In wetter areas the boardwalk may be supported on posts or stilts driven into the ground.

This is the most appropriate option for waterlogged areas, particularly in areas where the water level rises by more than a few cm in the rainy season. However, it requires a great deal of timber and is relatively costly. It also requires substantial labour.

Boardwalks require regular maintenance to repair joints and replace rotting timber.

Raised Path In less wet areas this may be the best option for a range of traffic.

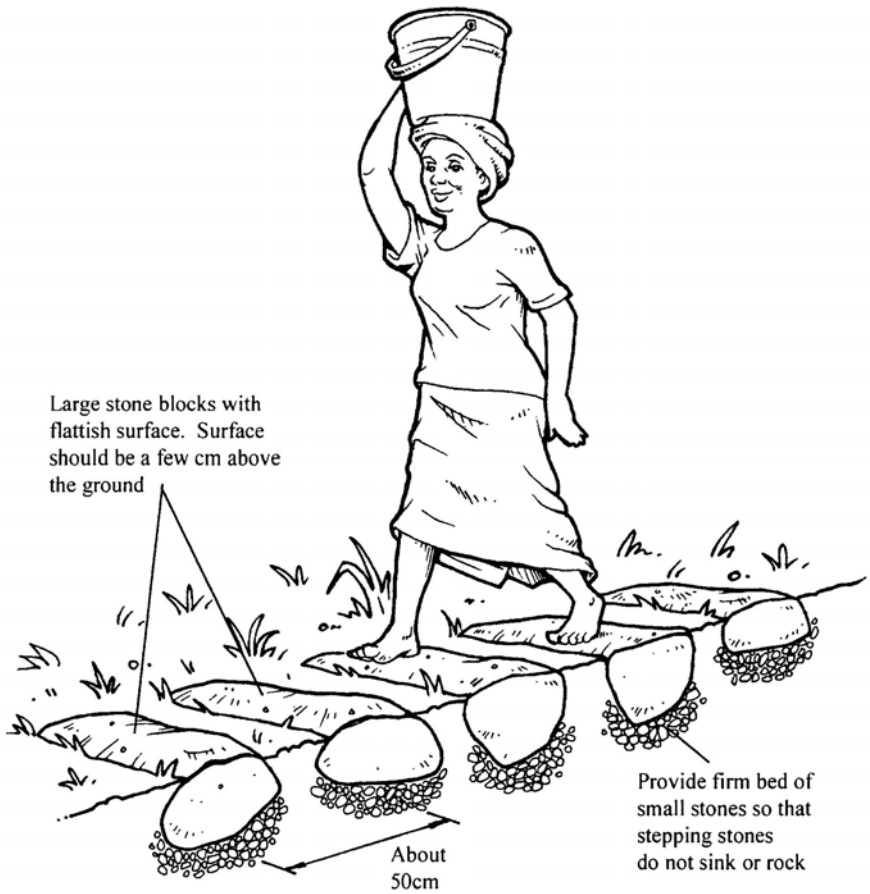
In wetter areas it will probably be necessary to bring in gravel and stone to provide a suitable path surface. This is likely to involve considerable transport problems and probably costs

In waterlogged areas, providing a stable base for the path will be a major problem. A raised boardwalk is likely to be a more feasible option.

3.5.1 STEPPING STONES

Stepping stones are the simplest method for improving a path which crosses wet or marshy ground. However they are not suitable for very wet areas where there is a rise of more than a few centimetres in the water level in the rainy season.

Figure 3.28: Stepping Stones



If large stones are not available, other possibilities are:

- Sections of tree trunks, at least 30cm in diameter
- Rock-Box
- Sandbags

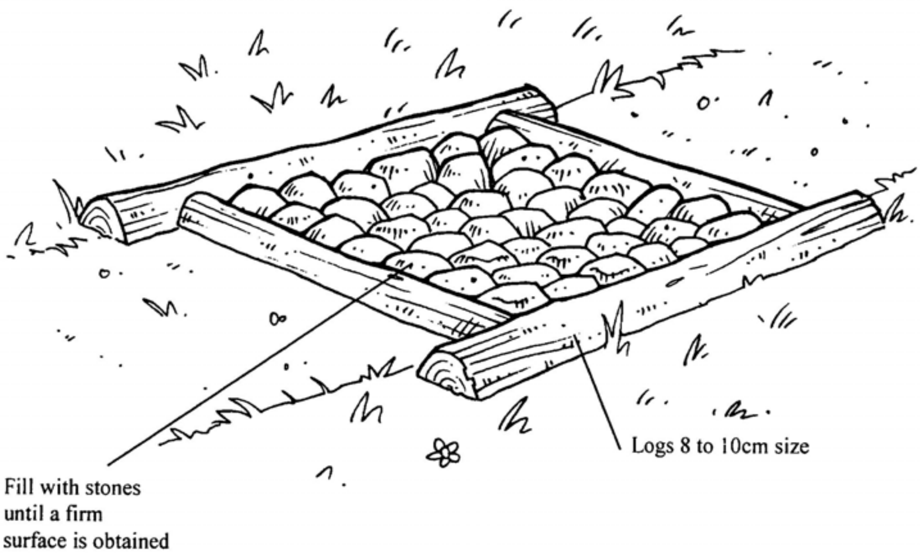
Rock-Box

A rock-box may be constructed which uses a large number of smaller stones. These stones are placed on the path in layers and compacted. This process is repeated until the stones stop sinking into the ground. In very wet areas this method may require a large quantity of stone and should only therefore be used for short sections (10m) of path.

The method may be used to construct stepping stones (minimum size 30cm x 30cm) or a longer section of path.

This construction method produces a rough surface that is difficult for animals or people to walk on. The surface may be improved by placing a thin layer of soil or sand over the stones.

Figure 3.29: Rock-Box



Sandbags

In areas where stones are not available, sandbags may be used filled with concrete. Sandbags should be filled with aggregate and cement in the proportion 6:1.

The bags are securely tied, laid on the surface of the path and tamped into position. They should then be watered and left for the concrete to set.

These may also be used as stepping stones or for a continuous short section of path.

Figure 3.30: Sandbags

3.5.3 BOARDWALKS

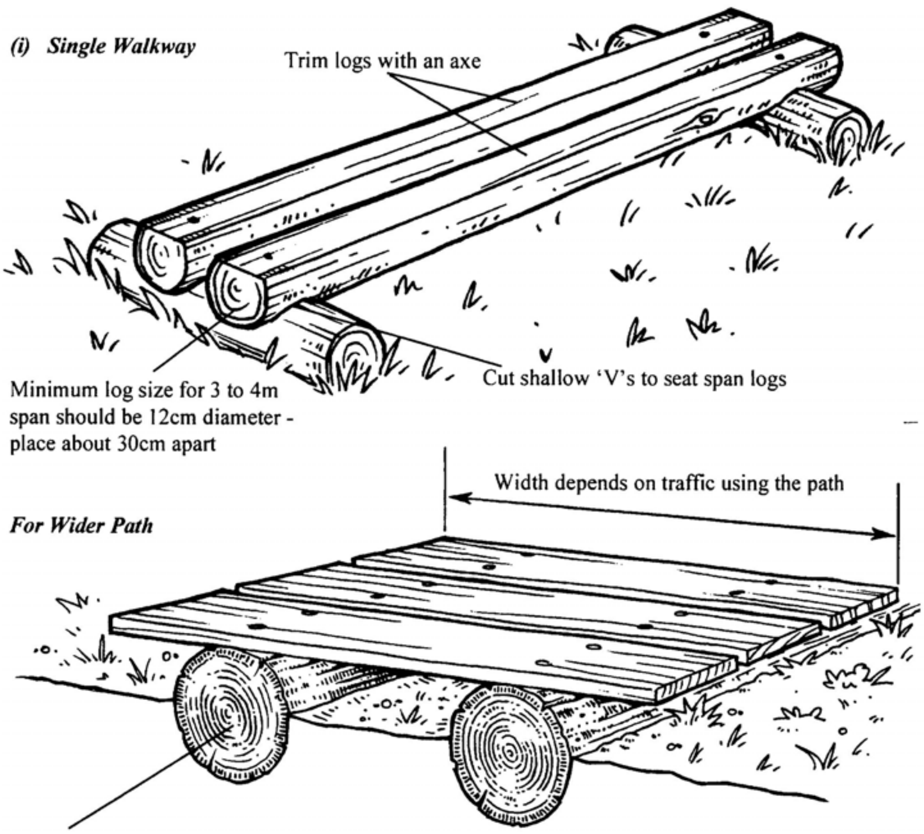
Boardwalks comprise logs placed on or above the ground to provide a firm path across the marshy area.

For less wet areas (Figure 3.31) the logs may rest directly on the ground or on sill logs at each end of the walkway.

A single walkway can be provided by trimming the surface of the logs with an axe to provide a narrow flat surface. For a wider path for more users and a range of traffic, boards can be nailed across the top of the logs.

For wet areas where the water level may rise by more than 20cm in the rainy season, boardwalks should be supported on posts (Figure 3.32).

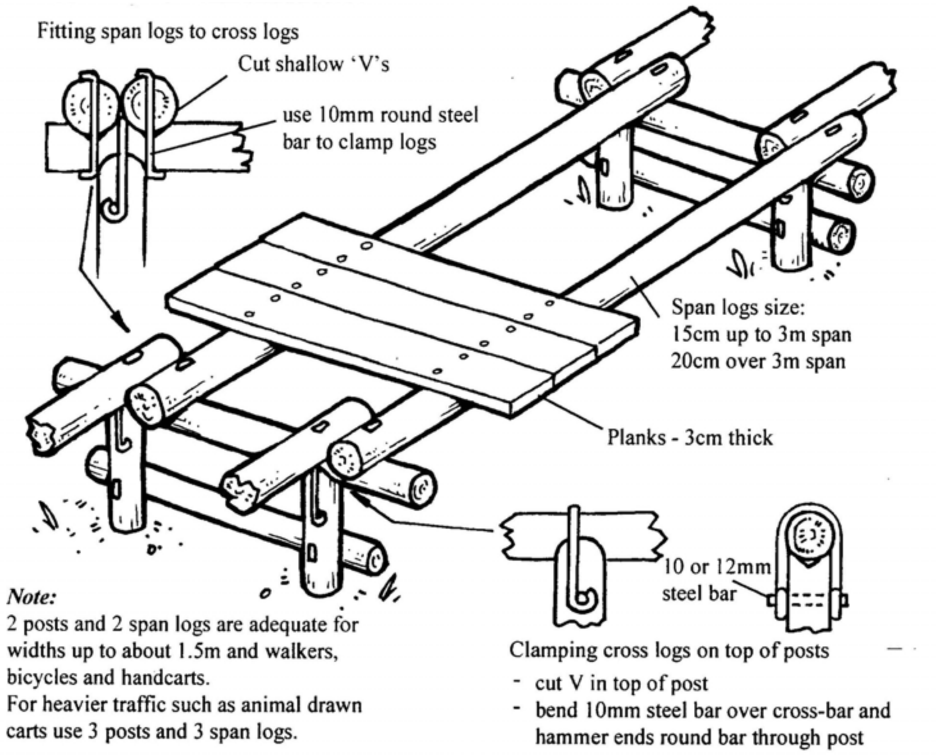
Figure 3.31: Boardwalks for Less Wet Areas

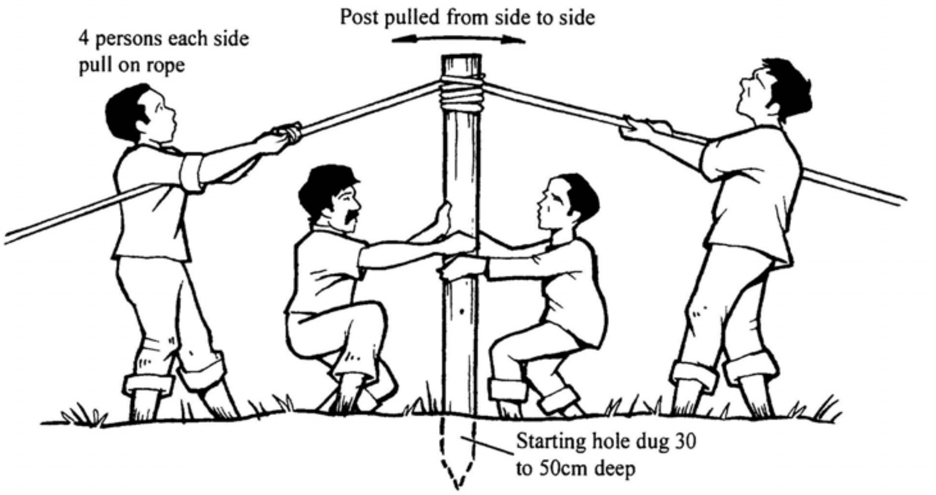


- Span logs can also be supported on sill or cross logs (as in (i)) to raise walkway
- For widths up to 1.5m, for walkers, bicycles and handcarts use 2 logs of about 15cm size spaced about 0.5 x width apart
- For heavier traffic and wider walkways use extra central log (3 in total) with spacing of 0.3 x width to each outer log

Figure 3.32: Boardwalk for Waterlogged Ground

This method is based on information supplied from Rufiji, Tanzania. Deck should be at least 20cm above highest normal flood level





"Swinging" method that can drive posts into soft marshy ground. Depths of up to 2m can be achieved. When complete, cut off post at required height above marsh

3.5.3 RAISED PATHS

If the path is to be used by a range of vehicles then a raised path may be the best option for less wet areas.

Raised paths use material excavated from the side ditches to raise the path or track above the surrounding ground. This construction method improves drainage in two ways:

- The slope on the surface of the path improves drainage of water off the path surface
- The side drains assist drainage of the ground under the path

It is important to have a firm base for the path surface which does not become waterlogged. Stones and rubble can be used if available.

The base for the path can be improved by placing a layer of *geotextile* material over the base material. This supports the added material (fill) and prevents it from sinking into the base material. It is particularly beneficial when the base material is wet and muddy. Geotextile material is plastic sheeting. Plastic sacks may also be used but must be well overlapped.

If geotextile material is not available, some improvement can be achieved by using a dense layer of thin branches.

The drains are very important both for draining water away from the base of the path and also preventing water from the surrounding marsh from reaching the base of the path.

What if logs are not easily available?

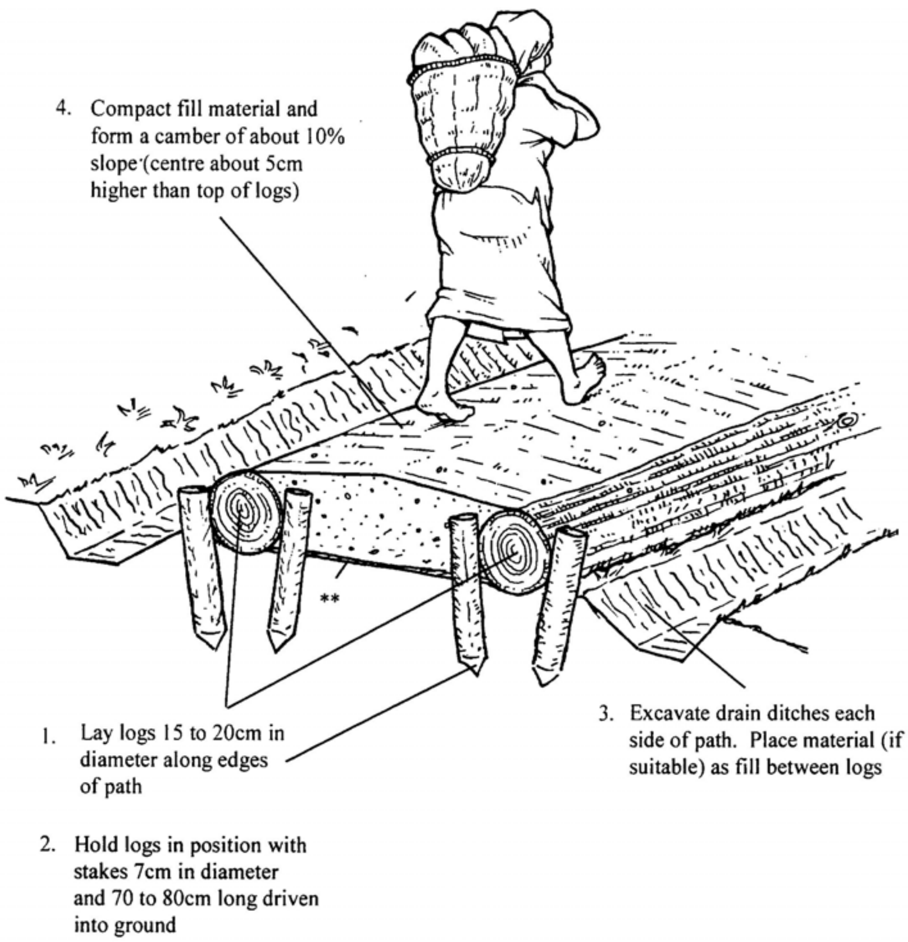
In areas where logs are not available they can be replaced by large stones or rocks. The rocks should be buried partly into the ground to fix them in place.

What if the ground is permanently waterlogged?

In areas where the ground is permanently waterlogged it may be necessary to use imported granular material between the logs rather than the material excavated from the ditches. This approach will significantly increase the cost of construction and maintenance of the path. If imported material is used to construct the path, the material excavated from the ditches should be spread away from the path.

In very wet areas it will be a major problem to provide a stable base for the path, particularly if the water level rises by more than a few cm in the rainy season. In these cases a more feasible option is likely to be a raised boardwalk.

Figure 3.33: Raised Path



Note: Choose the path width to suit the level of traffic expected.

** It is good practice to separate the fill material from the base material with a layer of geotextile material (plactic sheeting or plastic sacks) which will provide a barrier between the fill and the base material. If this is not possible, a dense layer of thin branches can be used to prevent the fill material sinking into the base material.

3.6 WATER CROSSINGS

Effective drainage is the most important factor in achieving a good footpath. Section 3.3 dealt with the drainage and removal of water from the path. This section describes the transfer of water across the path. This is required at stream crossings, dips in the footpath alignment and on sloping ground to transfer water from the high side of the path.

Two types of problems are dealt with in this section:

- Transfer of drain water or small streams across the path
- Crossing of narrow or shallow streams

The following options are considered:

Cross Drainage Option	Suitability
Cross Drains	• Occasional low volumes of water eg. After rain • Small dips in the footpath • Not suitable for wheeled vehicles
Culverts	• Low to medium flows of water • Suitable for all types of footpath users
Stepping Stones	• Streams or wide rivers with normal flow Depths up to approx 50cm • Only suitable for pedestrians*
Drifts	• Suited for wheeled vehicles to cross shallow streams, with depths up to about 30cm

*Stepping stones will not be suitable for animals or wheeled vehicles, although these users may wade or drive through the stream adjacent to the stepping stones if the stream bed is level firm and even.

Footbridges for larger streams and rivers up to 15m wide are considered an important topic by themselves and are covered in Chapter 4.

3.6.1 CROSS DRAINS

Cross drains are drains which carry water across the path. They are particularly needed on paths on side slopes to carry water away from side or catch-water drains from the uphill side to the downhill side of the path. They may also be used to carry small streams across the path.

If paths are only used by walkers, cross drains can be open. In this case the maximum width is 50cm and the flow capacity is limited.

To avoid erosion, cross-drains should be stone-lined, particularly where water flow is high. This will make the drain far more effective and longer lasting.

A typical drain is shown in Figure 3.33. More details on stone drains are given in Annex 1

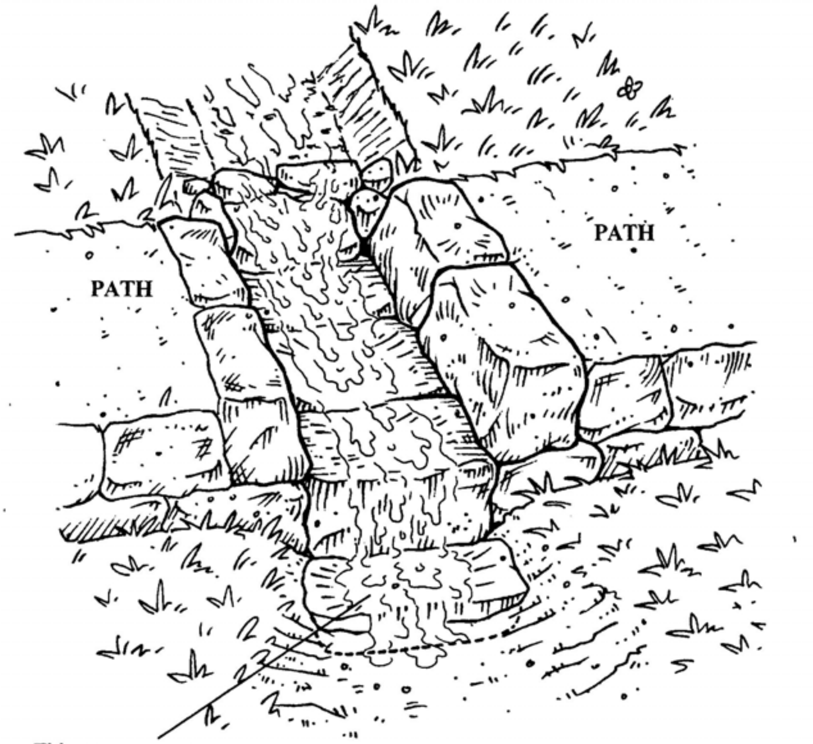
If wheeled vehicles use the path, cross-drains may be filled with stones as in *French drains* (see figure 3.18). However, these are only suitable for very low water-flow.

For higher water flow crossing paths which need to cater for a range of traffic, animals and wheeled vehicles, *Culverts* should be used (see section 3.6.2).

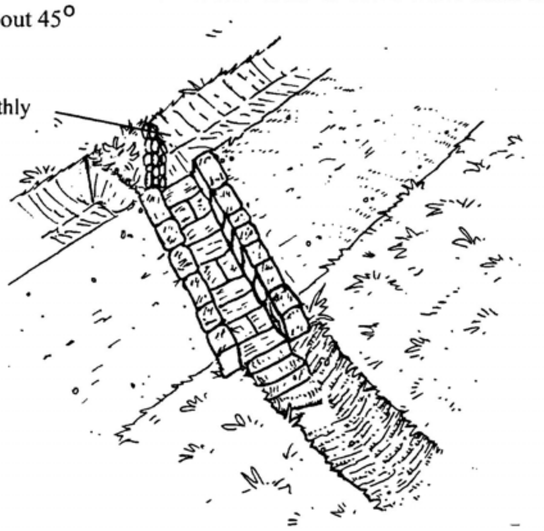
In the construction of stone drains, the stones should be big enough to form both the side of the drain and the surface of the path and heavy enough that they do not move when trodden on. Thin stones that merely line the drain are not sufficient and will soon get displaced. The drain can be up to 50cm wide and as deep as the side stones will allow.

To protect against scour the drain can be built by first lining the bottom with large slabs or boulders which are then held firmly in place by the side stones. Smaller stones may be placed at the inlet to help prevent material washing in and blocking the drain.

Figure 3.34: Stone-Lined Cross Drain



If the cross drain transfers water from a side drain or catch water drain it should be angled across the path at about 45°



3.6.2 CULVERTS

Culverts may be considered as an intermediate option between cross drains and footbridges. They can provide a water crossing for a range of traffic.

Because they can provide a much larger area for water flow than cross drains, culverts can handle large flows of drainage water across the path.

Three options are considered in this section:

1. *Bush Culverts* : this is basically a log bridge across the drain or stream. It is therefore cheap to construct, but the logs will need to be replaced periodically. Spans can be up to 2 to 3 m.

2. *Slab Culverts:* this uses stone slabs rather than logs. It is longer lasting but needs the availability of suitable stone slabs. It will therefore probably have limited use. The span is dependant on the size of slabs available and will probably be less than 1m.

3. *Pipe Culverts:* large pipes (at least 30 cm diameter but preferably 60cm) are used to transfer the water under the path. Fill is used around the pipes to build up the path surface. This is a relatively costly option which requires substantial work. It will mainly be appropriate if vehicles use the track.

***Summary**:* Bush culverts generally provide the most appropriate option for footpaths. The width can be readily selected to suit a range of traffic. HOWEVER, THEY ARE NOT SUITABLE FOR MOTOR VEHICLES.

The boardwalk designs described in Section 3.5.2 may also be used to span drains or small streams, making sure a solid foundation is provided for the support logs on each side of the drain/stream.

Bush Culvert

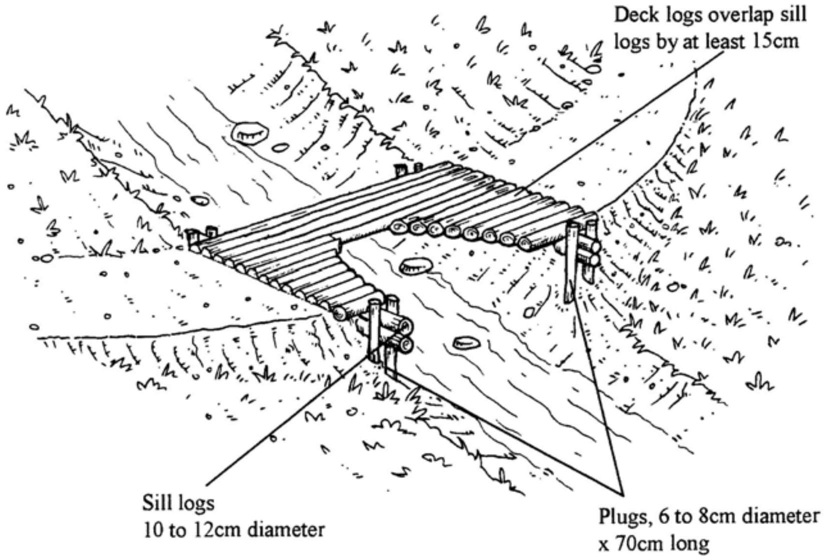
A bush culvert comprises a deck of wooden poles or logs placed over the open drain or stream. The width of deck should suit the level of traffic for which the path is designed.

The deck is supported on each side by sill poles. The number and method of support of the sill poles depends on the nature of the banks of the drain or stream. It is important that they sit on a firm, stable base and are held in position by plugs (post). Figure 3.34 shows a set-up with 2 sill poles each side.

The size of the deck poles depends on the type of traffic and span of the culvert. A guide is as follows:

Type of Traffic	Minimum Size of Deck Logs for Various Spans		
	1m	2m	3m
Walkers only	8cm	10cm	12cm
Carts	10cm	12cm	15cm

Figure 3.35: Bush Culvert



Note: If wheeled vehicles use the path, the culvert needs to have a flat surface. Although the spaces between the logs may be filled with clayey soil or grass sods laid over the logs, the soil tends to hold moisture and cause rotting of the wooden logs. However, this can be reduced by placing a layer of *geotextile* material over the logs. For longer life it is better to nail sawn planks on top of the logs. In this case the construction is similar to a log footbridge and the guidelines given in Chapter 4 can be used.

Slab Culvert

Slab culverts are similar to stone cross drains except that they have a cover over them to enable pedestrians and vehicles to pass over them. The maximum size of culvert will be determined by the size of stones available for the side and top slab of the culvert.

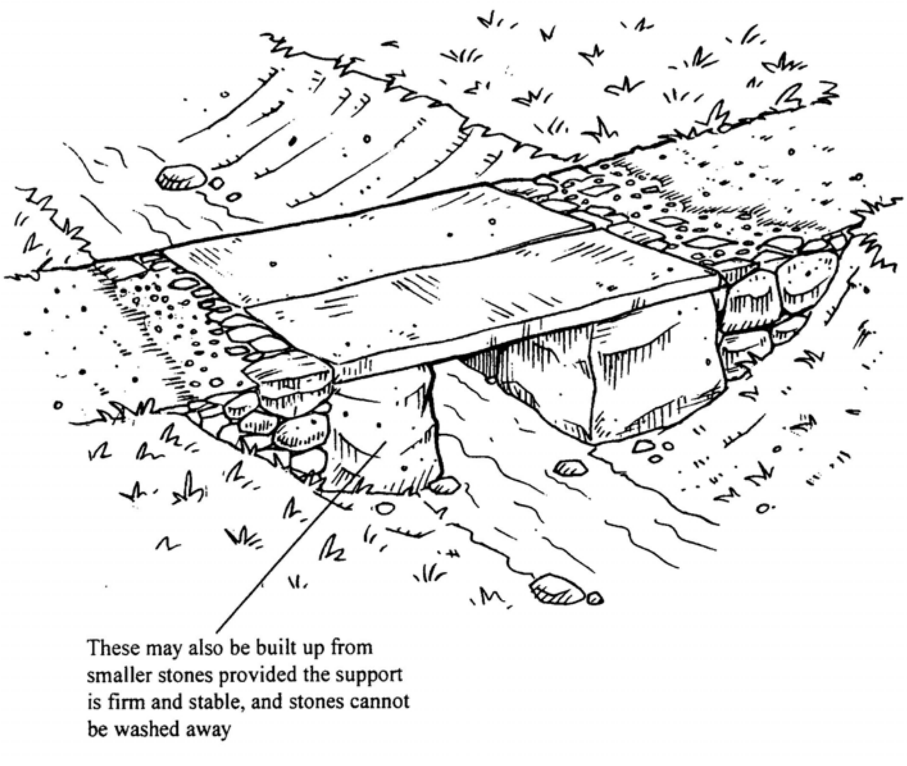
Method of Construction:

1. Place large stones either side of watercourse, across the whole width of the path and ensuring that the stones do not partly block the water flow;

2. Place flat stones over the stream between the large stones on each side.

3. Fill and compact the area behind the large stones with gravel and earth to the level of the path.

Figure 3.36: Slab Culvert



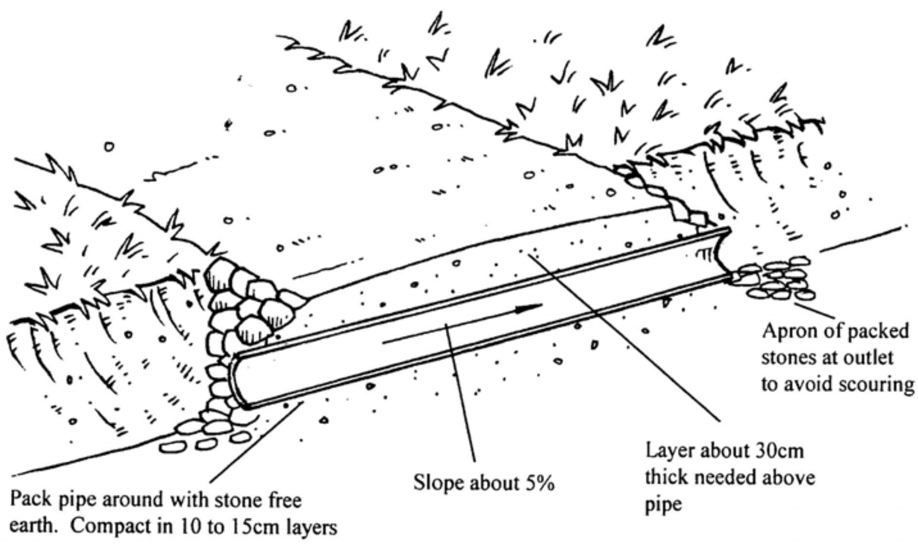
Pipe Culvert

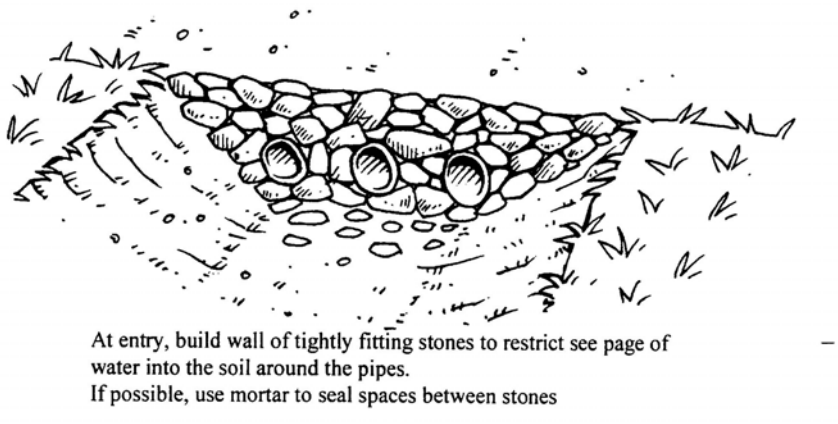
Pipe culverts provide a crossing over shallow streams up to several metres wide which is suitable for all types of users.

Pipes are normally at least 30cm diameter. To allow ease of cleaning a 60cm diameter is preferred particularly for lengths over 1m. The cost of pipe culverts is therefore relatively high and considerable work is involved in construction.

They are probably not justified unless there is a need for motorised vehicles to use the track.

Figure 3.37: Pipe Culvert





3.6.3 STEPPING STONES

Stepping stones are suitable for any width of stream or river, providing the water depth is less than 50cm.

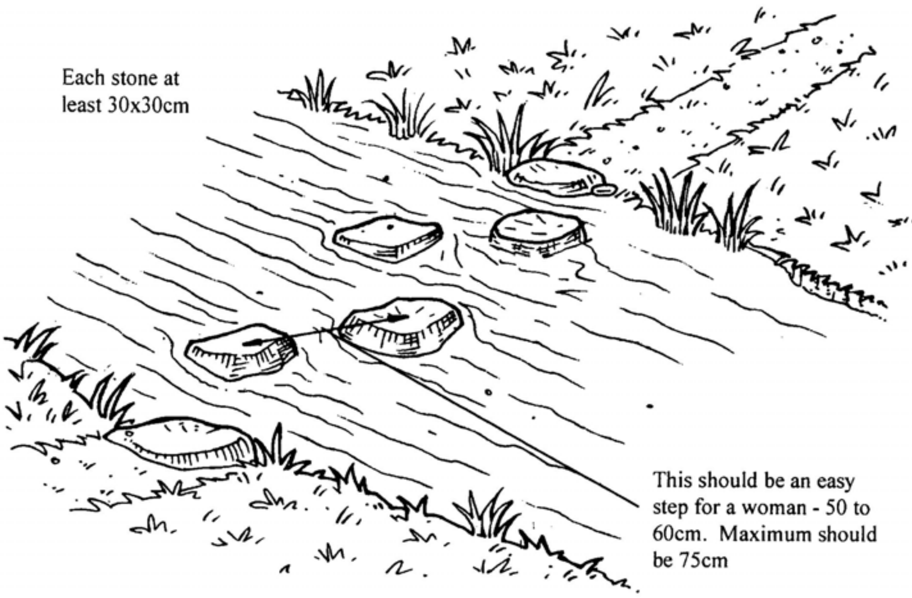
Stepping-stones should be placed at a spacing of about 50 to 60cm between stones with a maximum spacing of 75cm.

Each stone should:

- Have a flat step area of at least 30cm x30cm
- Be 10cm above the water for normal flow levels
- Be large enough not to be washed away during floods
- Be stable and not rock when walkers step on them
- Preferably not be slippery when they are wet

The use of stepping stones can be made safer by providing *tight* rope guides on each side of the crossing.

Figure 3.38: Stepping Stones



3.6.4 DRIFTS

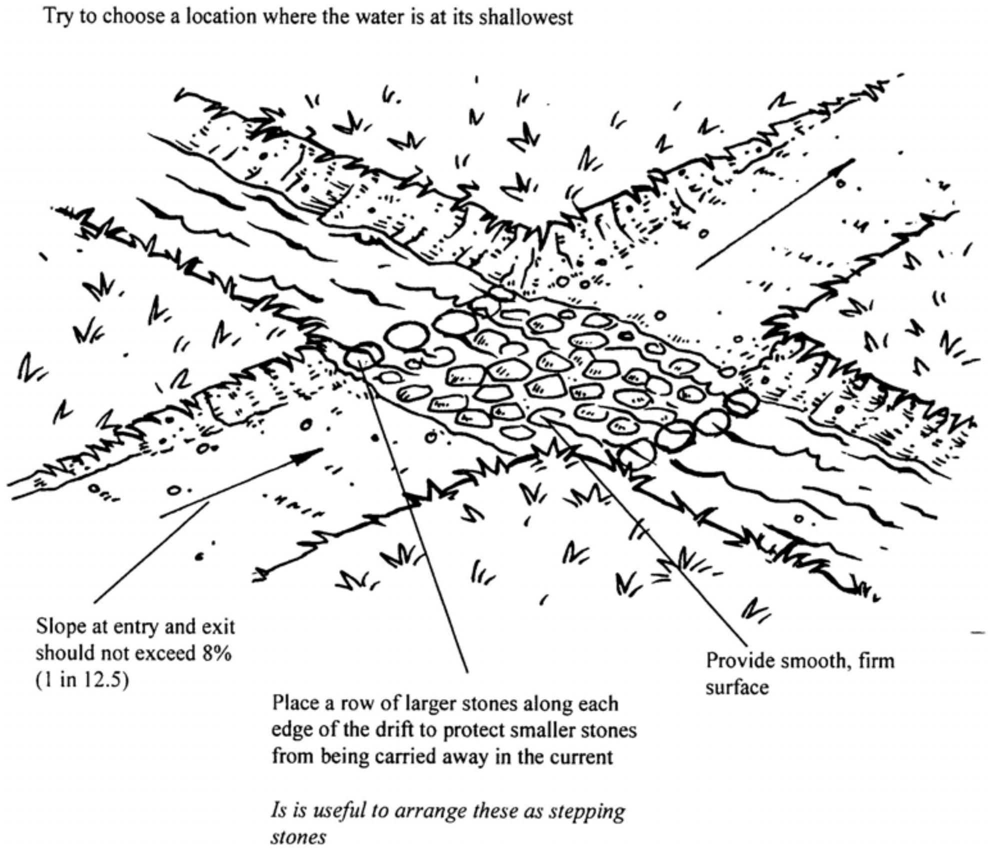
A drift can be used to cross a shallow stream especially when wheeled vehicles use the path. It should be located where the stream is shallow enough for walkers and vehicles to cross without any problems.

The main construction required is to excavate suitable approach and exit ramps so that wheeled vehicles can easily enter and exit the drift. The slope of these ramps should not exceed 8% (1 in 12).

The drift should have a firm, level bottom across the stream so that wheels do not sink in. A smooth, stony surface is best.

Note: it is possible that water flowing down the approach or exit slopes may cause erosion of the path. A simple method of dealing with this is to construct a side drain on the DOWNSTREAM side of the path, with a cross fall on the path to cause the run-off to flow into the side drain. The side drain should exit downstream of the drift.

Figure 3.39: Drift Water Crossing



4. FOOTBRIDGES

Lack of adequate footbridges is often one of the mains barriers to access in rural areas. In many cases bridges over small streams comprise just logs which are likely to be submerged and washed away in the rainy season, cutting off access along the path.

Construction of more permanent bridges that provide access throughout the year requires good planning and design. I*n particular* they need proper location and construction of abutments which raise the bridge above the highest water level and which will not be washed away.

This chapter gives details of simple footbridges for spans up to 15m. Larger spans require more complex and costly designs such as bridges with piers or suspension bridges. These are beyond the scope of this manual. Also for wider spans, the construction of a bridge may need to be compared with the use of a ferry.

4.1 PLANNING AND LOCATION OF FOOTBRIDGES

Location/Site Selection Key Issues

- Use the shortest possible span
- Select a sight with good foundation conditions
- The site should be as close as possible to the existing path alignment
- The approaches should be across well drained ground to avoid poor paths

Level of Footbridge

The deck of the footbridge should be above flood level to

- Ensure travellers can cross the water course even during floods (the approach paths should also be above the flood level)
- Minimise potential damage to the structure

This can be ensured by:

1. Site observations – signs of debris caught on vegetation, tide marks, sand deposits
2. Interviews with local population of existing flood levels (beware of exaggeration)

Footbridge Options

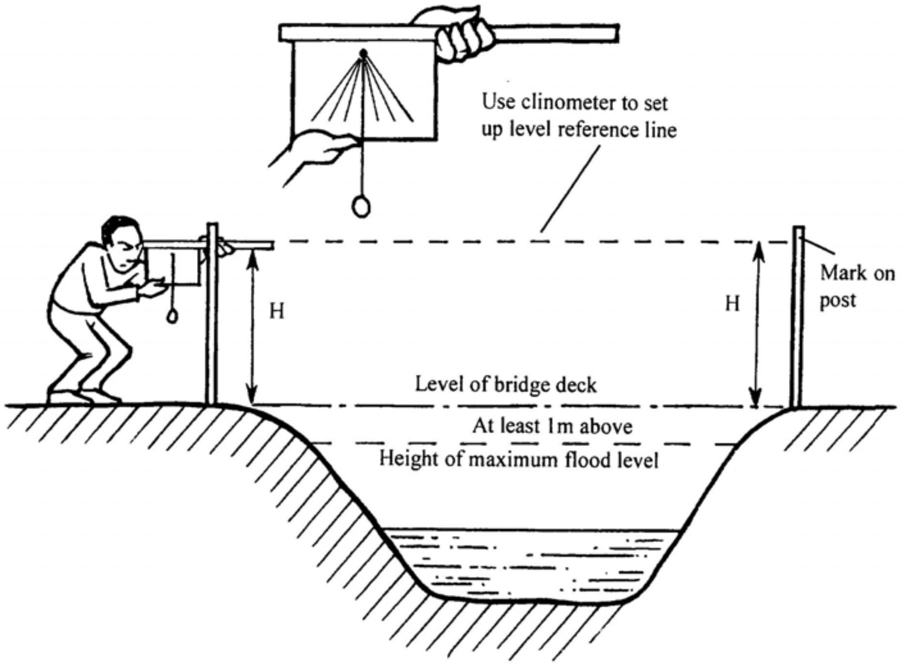
For short spans up to 15m bridges can be constructed from a combination of:

- timber - this will usually be the most appropriate taking into account local resources and skills. It is likely to be the least cost option
- concrete/masonry - this will provide a longer lasting construction which is less likely to be washed away. The simplest form will be a culvert. The cost is likely to be higher than timber
- Steel - this is likely to involve fabrication of sections in a local workshop and transport to site for assembly. It is not an option often found and few proven designs are available. It may be more costly than timber but is more durable.

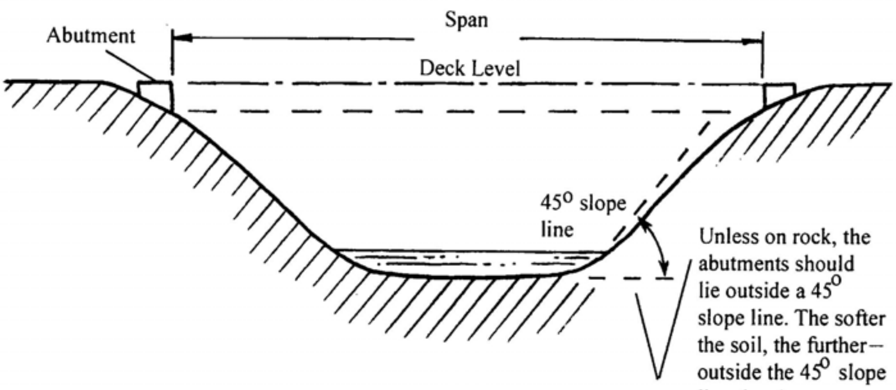
Footbridges comprise two basic components:

- The *abutments* which support the deck of the bridge on each side of the river/stream
- The *deck* which provides the carriageway for traffic

Figure 4.1: Setting out the Bridge



Note: the bridge should be perpendicular to the river/stream



4.2 FOOTBRIDGE ABUTMENTS

Footbridges require supports at each end to support the deck (the platform that travellers walk across). These supports, called abutments can be built from timber or masonry or a combination of both. They should be at the same level each side.

The design and construction of abutments depends on the bank conditions and required height of the bridge deck. They must be stable (not rocking or sinking) and secure as possible against being washed away.

Options for Abutments:

4.2.1 GROUND LEVEL BRIDGE DECKS

The simplest form of abutment is a *sill* similar to the type used for *boardwalks* (see section 3.5.2 and Figure 3.31).

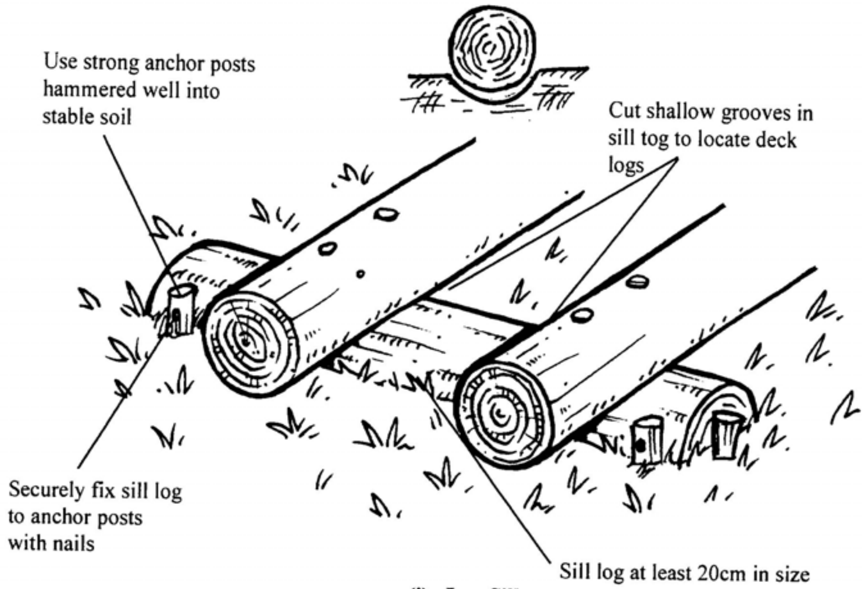
This is suitable for short span, low traffic footbridges where there is no need for a raised support for the deck of the bridge.

The sill logs should be held in position by stakes hammered into the ground and the deck logs securely attached to the sill log with either steel rods or nails

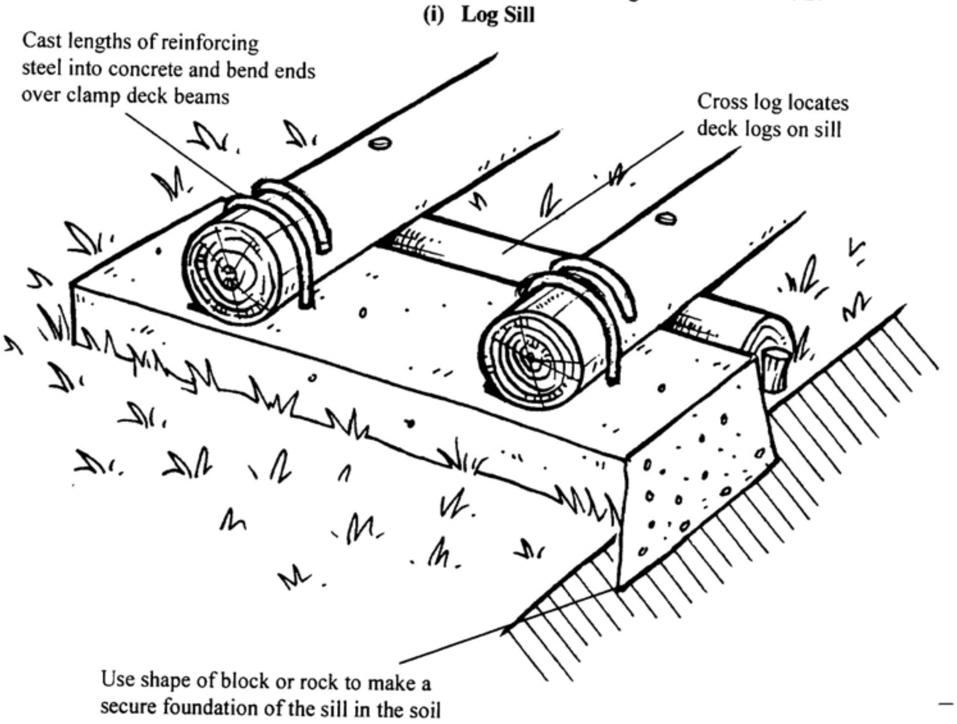
Sills may also be made from large stone slabs, concrete slabs, or smaller stones bound together with mortar. The deck must be securely located on the sills.

Figure 4.2 shows some simple arrangements for sills

Figure 4.2: Sill Type Abutments



(i) Log Sill

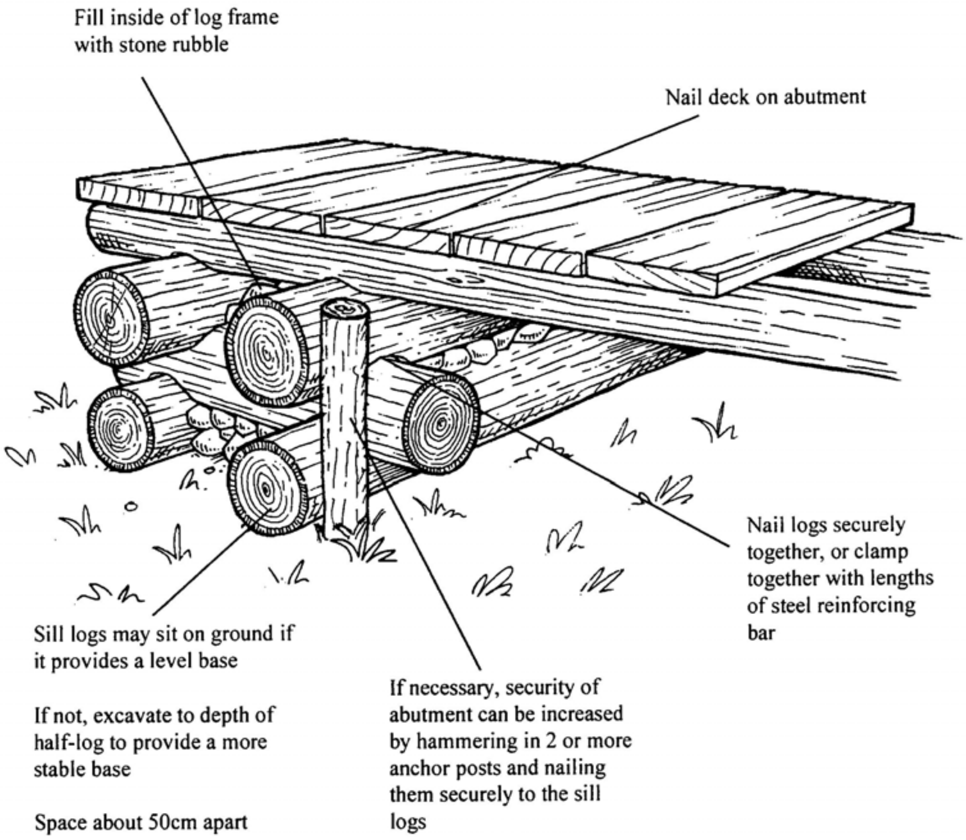


(ii) Stone or Concrete Sill

4.2.2 RAISED BRIDGE DECKS

If the bridge deck has to be raised to be above the highest water level (rainy season) then a more substantial abutment will be needed. A few options are described below

Figure 4.3: Timber Crib with Stone Rubble Fill

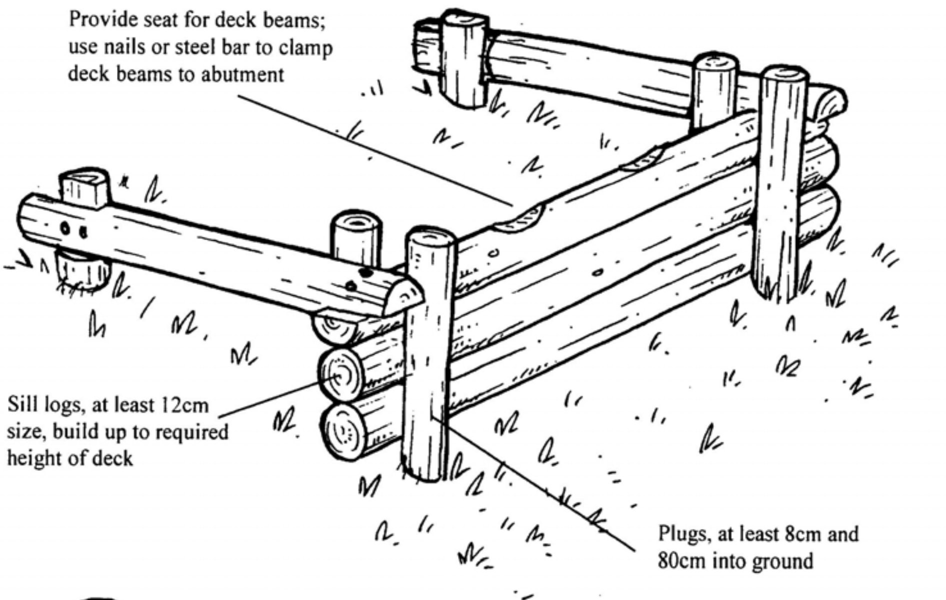


Notes:

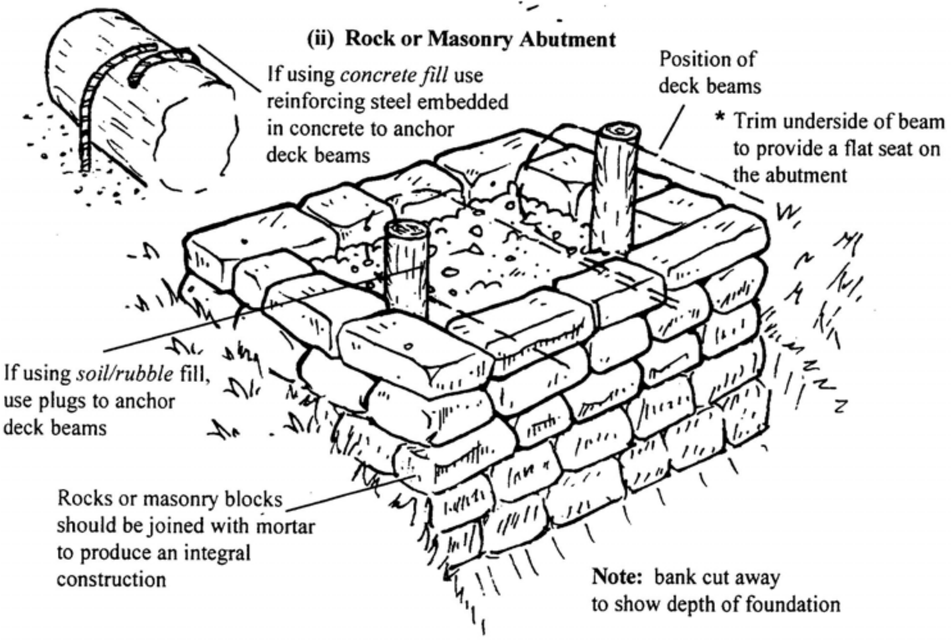
1. Depending on size of bridge:
   - sill logs 10 to 15cm size
   - anchor posts (plugs), 6 to 8cm size
2. Deck logs must be securely located on and attached to sill logs

Figure 4.4: Other Options for Raised Abutments

(i) Timber Log Abutment



(ii) Rock or Masonry Abutment



4.3 DESIGN OF TIMBER BRIDGES

This section provides guidelines on the design of simple wood/timber bridges for spans up to 15m. It covers log bridges and sawn timber bridges. Designs of the two types of bridge decks are shown in Figure 4.5.

4.3.1 DECK MADE FROM LOGS

The deck structure comprises 2 to 4 logs which rest on the abutments at each end. The number of logs depends on the width of the deck and the weight of traffic.

The logs support a platform usually made of sawn timber planks. These will be the main cost of the bridge.

A more crude platform that has little or no cost can be made from wooden poles, up to 10cm in size which may be nailed or bound to the logs. This type of platform will not be as convenient or comfortable for users.

The support logs should be stripped of bark and wherever possible the surfaces soaked with creosote or some other form of wood preservative.

The recommended minimum sizes of logs for a range of bridge types and spans are given in the tables below.

1. Bridges for people only – walkers and bicycles

Bridge Capacity	**Number of logs**	**Minimum log size (cm) for specified span**				
		3m	6m	9m	12m	15m
1-way	2	14	25	30	35	48
2-way	2	16	25	33	42	50
	3	15	24	32	40	48

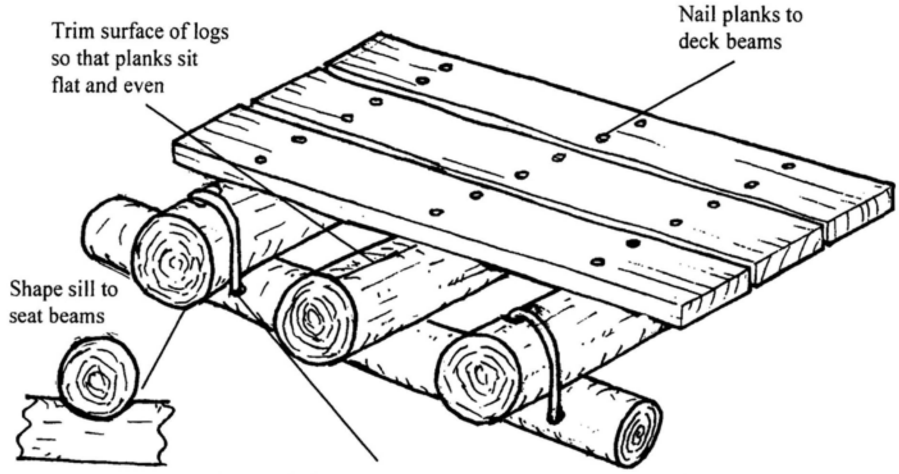
2. Bridges for Animal–Drawn Carts

Bridge Capacity	**Number of logs**	**Minimum log size (cm) for specified span**				
		3m	6m	9m	12m	15m
1-way	4	25	30	35	45	50

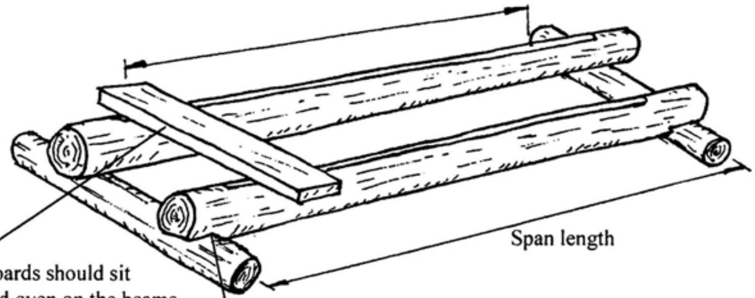
Note: - The above design is for 1 cart only on the bridge at any time. A warning sign should be put up stating this condition. It is not considered cost-effective to make bridges strong enough for more than 1 cart at a time since the crossing time will be less than 30 seconds and waiting times will be low.

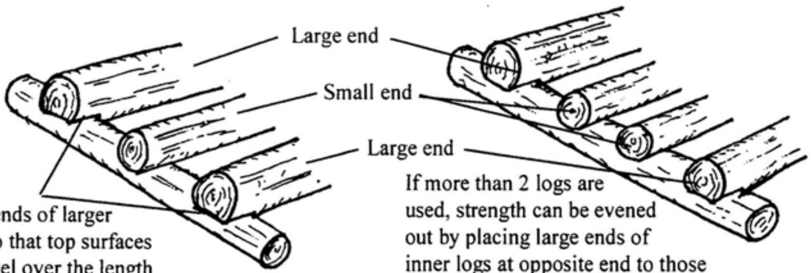
Important: *The minimum log size needs to be maintained over at least the central 75% (3/4) of the span. Size is diameter after bark is stripped off.*

Figure 4.5: Construction of Timber Decks – Log Beams



Important:
1. Maintain minimum log size over at least the central 3/4 (75%) of the span length
2. Not more than 1cm for 20cm size up to 2.5cm for 50cm size should be trimmed off log surface





4.3.2 DECK BEAMS MADE FROM SAWN TIMBER

Decks using sawn timber beams are neater and simpler to make, but likely to be considerably more costly than using logs. It may be possible to obtain logs from a forest which will involve considerable time and effort but probably little cost. Sawn timber will probably have to be purchased from a supplier but may be delivered to site.

Because of its cost, sawn timber needs to be used efficiently. Therefore the depth of beams should be large compared to the width (thickness). Doubling the width of a beam doubles the strength but doubling the depth increases strength by a factor of 4 (i.e. x 2^2) and stiffness (reduced bending) by a factor of 8 (2^3). ***However***, for stability the depth should not be greater than 4 x width For the same strength, a rectangular beam with width/depth of 1:4 weighs only about 56% of a round log.

The recommended sizes (depth) of sawn beams for a range of bridge types and spans are given in the following tables. The sizes are given for width/depth ratios of 1:4. Because of their shape more sawn beams can be fitted in the deck width, therefore giving greater choice in beam sizes.

1. Bridges for People Only – Walkers and Bicycles

Bridge Capacity	Number of Beams	Minimum Beam Size (depth) in cm for Specified Span				
		3m	6m	9m	12m	15m
1-way	3	12	20	25	32	40
	5	10	16	22	28	33
2-way	5	14	20	28	36	42

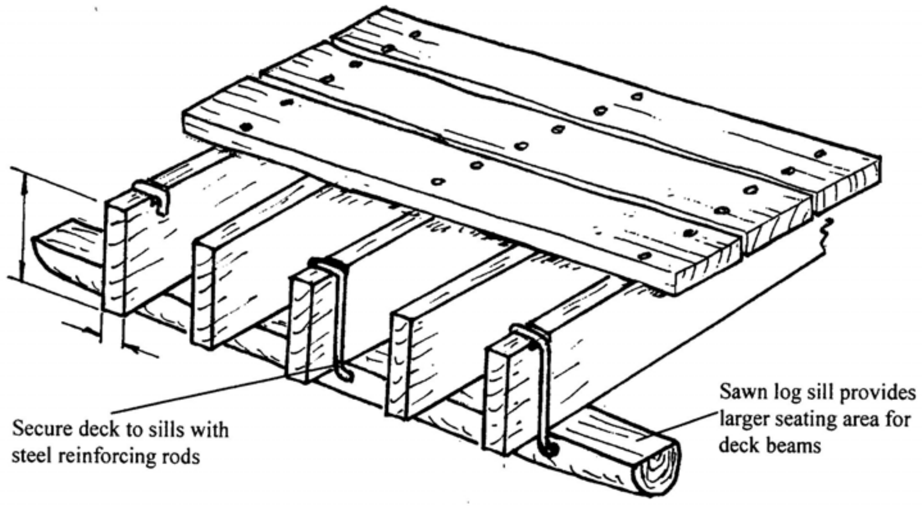
***Note:* -** The beam sizes given are for a width/depth ratio of 1:4; i.e. thickness = depth/4

2. Bridges for Animal-Drawn Carts

Bridge Capacity	Number of Beams	Minimum Beam Size (depth) in cm for Specified Span				
		3m	6m	9m	12m	15m
1-way	6	22	32	38	42	48
	8	20	30	34	38	42

***Note:* -** The beam sizes given are for a width/depth ratio of 1:4; i.e. thickness = depth/4

Figure 4.6: Construction of Timber Decks – Sawn Timber Beams



4.3.3 MINIMUM DECK WIDTHS

The minimum deck widths and plank sizes needed for different types of traffic are given in the following table

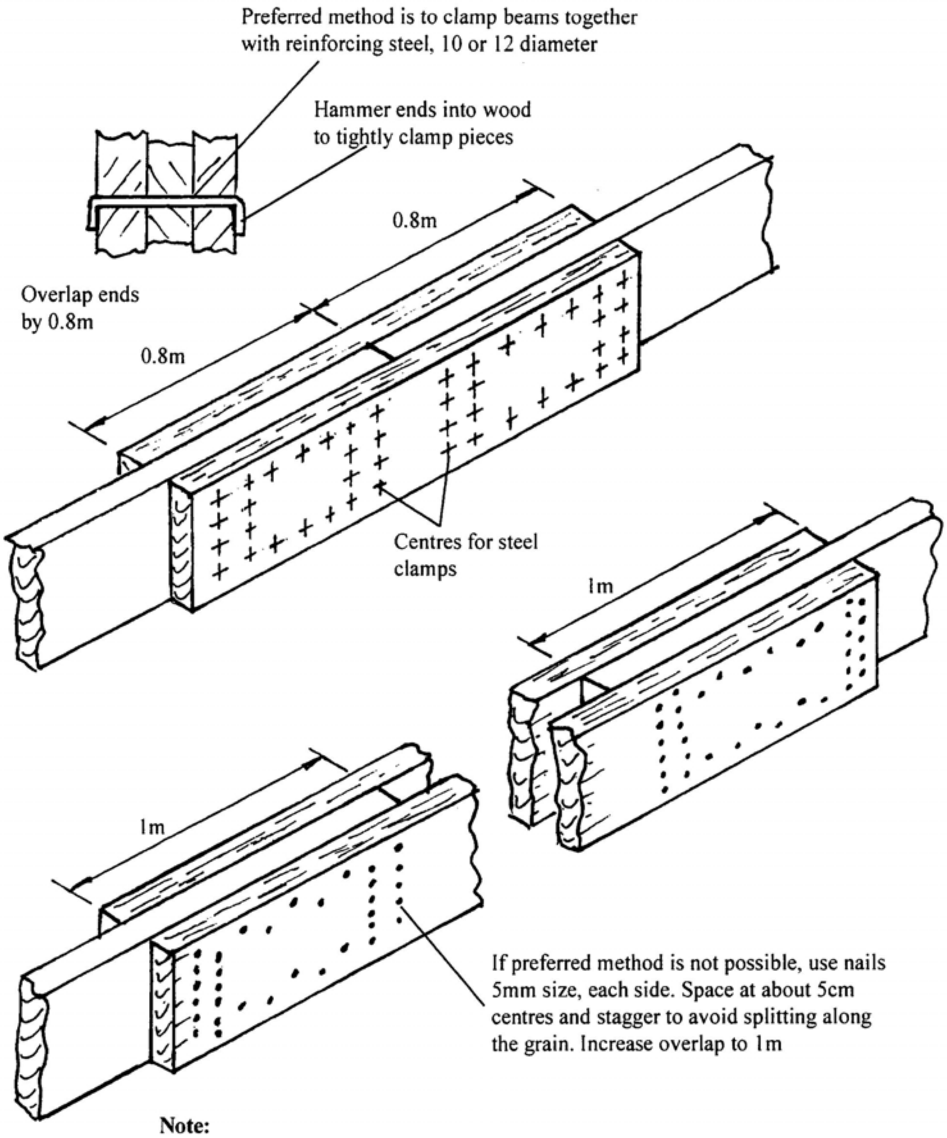
Type of Traffic	Minimum Deck Width (m)	Minimum Plank Size Width x Thickness	Notes
1. Single-Way Pedestrian	0.8m	20 x 5cm	This will allow a wheelbarrow but involves some risk for a bicycle
2. Two-Way Pedestrian	1.2m	20 x 5cm	Also suitable for a single pack-animal
3. Single Bicycle	1.4m	20 x 5cm	A bicycle-trailer may cross with care, a small handcart will be risky
4. 2-Way Bicycle	2.0m	20 x 5cm	This adds considerably to cost and is not justified unless traffic level is high, say more than 50 bicycles in <u>each</u> direction in any hour on a regular basis
5. Animal-Drawn Cart	2.4m	20 x 7.5cm	<u>Only one</u> should cross at a time Put up warning sign

Notes: 1. Making footbridges wide enough for vehicles (IMT) is costly. On the other hand if the bridge is not wide enough the vehicle will not be able to cross. Careful consideration must therefore be given to the types of vehicles which will need to use the bridge.

2. A bridge width of 1.4m will allow IMT up to medium-size handcarts and pack animals to pass. For large hand carts and animal-drawn carts a width of 2.4m will be needed with kerbs.

3. The time to cross the bridge will be less than 30 seconds. Designing for 2-way vehicle traffic is NOT justified unless traffic levels are high on a regular basis.

Figure 4.7: Joining Sawn Timber Beams



Note:
It is important to follow the patterns of centres shown in order to achieve the required strength in the joints

The aim is to achieve the maximum resistance to twisting in the joints between the clamped member

4.3.4 CHOICE OF DESIGN

The choice of deck design will depend largely on whether logs which are suitable both in type of timber and size are available locally.

Preferred timbers, both logs and sawn sections, are hardwoods which are durable, resilient (resistant to shock loading), do not split easily and are reasonably readily available.

The advantages of logs are low cost and a greater possibility of being available in long lengths.

Sawn timber allows neater and simpler construction and has a better strength/weight ratio.

A rectangular beam with a width/depth ratio of 1:4 weighs only 56% of the weight of a round log of the same strength. Also since more rectangular beams can be used then the individual weight of sawn timber beams can be considerably less than logs so that they are much easier to handle.

Sawn timber can be found in most rural centres, although not always in the section sizes and lengths needed for bridges. However, lengths of sawn timber can be joined to make longer beams as shown in Figure 4.6. It is difficult to join logs.

4.3.5 ERECTION OF TIMBER BRIDGES

The main problem is to lift the beams into position on the abutments. They should be lifted individually and attached firmly to the abutments.

The weight of a 30cm diameter log is about 55 to 60kg/m and a 40cm log about 100kg/m. The weight of log beams may therefore be 1 tonne or more. A labour force of 15 to 20 may be needed with ropes and levers.

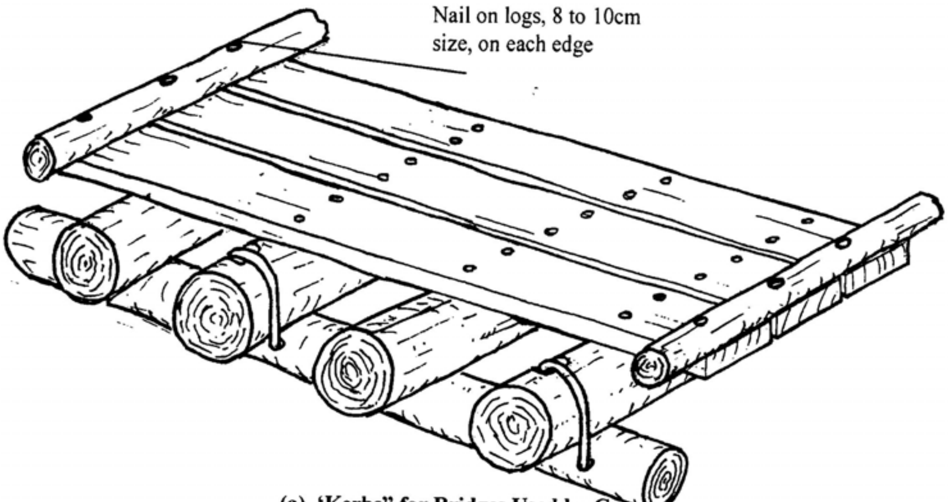
Once the beams are in position and clamped to the abutments the deck boards can be attached, working from one side.

Kerbs: if carts are to use the bridge it is advisable to fix log kerbs each side as constraints to wheels running off the deck (see Figure 4.8). Logs should be 8 to 10cm diameter.

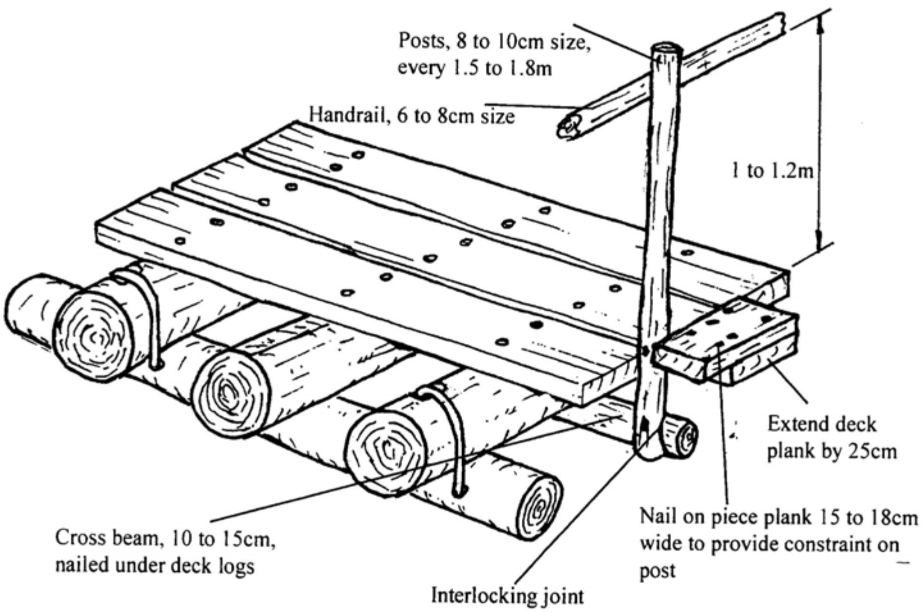
Handrails: for bridges of greater than 6 to 8m span a handrail on one side is advisable (see Figure 4.8). However:

- Handrails must be adequately strong and firmly and reliably attached to the deck structure;
- They must also be regularly checked to make sure they remain reliable and safe;
- *Remember that it is better not to have a handrail than to have one which is not safe and reliable.*

Figure 4.8: Design Features for Footbridges



(a) 'Kerbs" for Bridges Used by Carts



(b) Handrail

DESIGN OF MORE COMPLEX FOOTBRIDGES

The footbridges described in this manual are for relatively short spans up to about 15m and for reasonably flat to rolling terrain.

More complex designs will be needed for wider spans and for mountainous areas where bridges cross deep gorges.

For wider spans in relatively flat areas, either decks supported on piers or suspension type bridges are commonly used.

For mountainous areas, suspension type bridges are used.

Both these types, particularly suspension bridges, are more technically complex and are beyond the scope of this manual.

Sources of information on these types of bridges are given below:

4.4.1 GENERAL DESIGN OF FOOTBRIDGES

Readily available information on the design and construction of footbridges is limited and that available has been generally prepared for engineers and is quite technical.

The ILO-ASIST sourcebook on labour-based technology lists only one publication on bridges:

TRL Overseas Road Note 9: A Design Manual for Small Bridges
Published by Transport Research Laboratory (TRL) Overseas Unit, Crowthorne, UK, 1992.
Available from ILO-ASIST Information Services (see Annex 5), Ref.no. 00592

Although this book deals with road bridges, it provides a useful reference on a range of single-span and multi-span bridge designs with maximum individual spans up to 12m. The main coverage is of concrete bridges, there is only a relatively short section on timber bridges. The manual provides a comprehensive set of guidelines for highway engineers on the planning and design of small bridges and also of culverts.

Timber bridges*:* the following publications deal specifically with wooden bridges

TRADA: Prefabricated modular wooden bridges
Timber Research and Development Association, High Wycombe, UK, 1990

Jules Janssen: Building with Bamboo
Intermediate Technology Publications, London, 1995

The book has a short section giving practical guidelines on construction of footbridges from bamboo. The design comprises short spans supported by piers made from bamboo poles and is therefore applicable to soft river beds that provide secure support for the piers and where the deck of the bridge has to be no more than 5m above the river bed.

4.4.2 DESIGN OF SUSPENSION BRIDGES

The following publications provide a good, detailed coverage of these types of bridges which are particularly suited to hilly areas.

ITECO: Survey, Design and Construction of Trail Suspension Bridges for Remote *Areas*
Published by SKAT (Swiss Centre for Appropriate Technology), St.Gallen, Switzerland, 1983

This provides extensive engineering data on the design and construction of suspension and suspended bridges based on development work in Nepal. All the information needed to design and analyse the bridges is given.

ILO-ASIST: Design and Construction of Suspension Footbridges
Prepared by Eng. E.V. Chipuru for ILO-ASIST, Harare, Zimbabwe, 2000

The Guideline covers general aspects of suspension footbridge construction including, site investigations, estimation of quantities, tendering for contractor execution, construction procedures, resource management and maintenance of completed bridges. It does not provide information on the detailed design and analysis of suspension bridges.

5. MAINTENANCE

5.1 INTRODUCTON

Ongoing maintenance of the improved footpath or track is essential to sustain the benefits obtained from the improvements. Without this, the benefits will soon be lost and all the time and effort involved will be wasted.

Although this is an extra task for the community, the time and effort spent on regular, year-round maintenance will be far less than allowing the path to deteriorate over a few years and then having to rehabilitate it again to provide adequate access.

The need to include an ongoing maintenance programme in the agreement with the community was discussed in Chapter 2. This chapter outlines the activities required for an effective maintenance programme.

There are three types of maintenance activity that are required to be undertaken

Routine Maintenance

Regular and continuous work to reduce path deterioration and thus prolong its lifespan, make it more comfortable for the user and increase user safety.

Periodic Maintenance

More substantial work carried out at intervals of a year or several years

Emergency Maintenance

Work undertaken after flooding or landslide etc to reopen or keep the path open for users.

The main routine maintenance activities that are required for footpaths are illustrated in Figure 5.1.. Table 5.1 similarly lists the routine and periodic maintenance activities needed for the main features that deal with particular problems.

REMEMBER

1. Carry out routine maintenance on a regular basis. If it is left, problems can soon build up and require major work. For example, if drains are not cleaned water may flow over the path and damage the path surface.

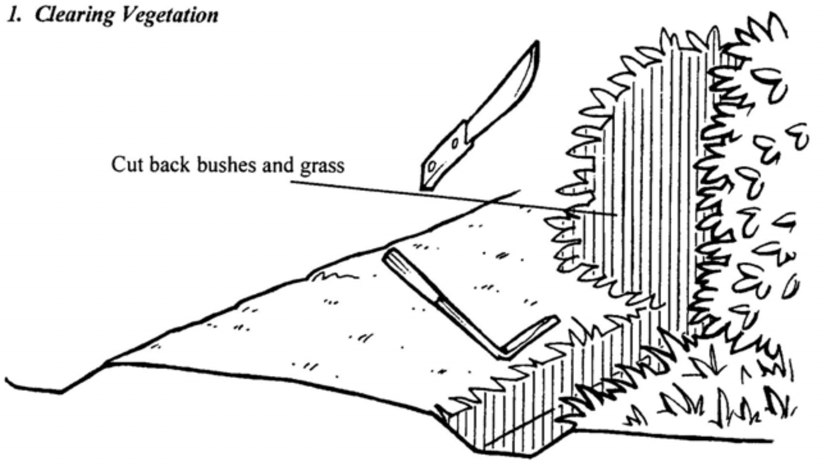
   Small jobs which are left can soon become major jobs.

2. A small amount of time and effort spent regularly on routine maintenance can save much time and effort in the longer term

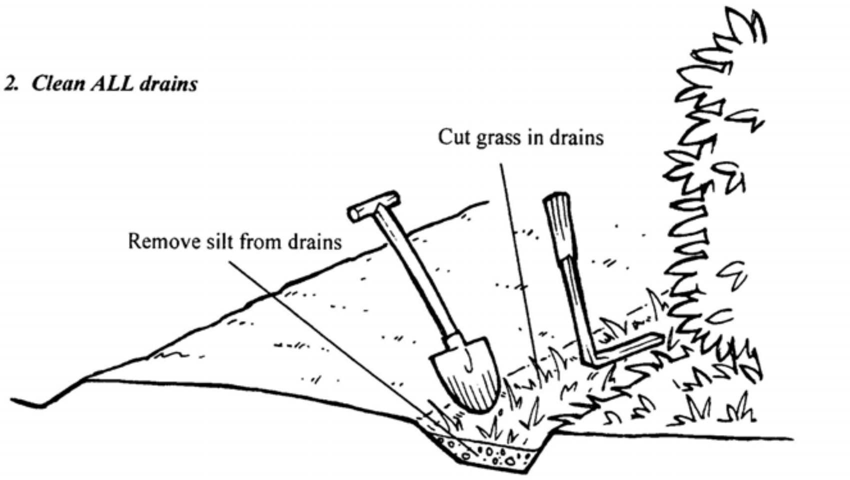
5.2 MAINTENANCE ACTIVITIES

Figure 5.1 shows the main activities which need to be carried out on a routine basis to keep the path in good condition and to guard against serious damage

Figure 5.1: Main Activities in Routine Maintenance of Footpaths



- Cut back bushes and grass to clear the formation width (path and drains) of the path
- In particular cut bush to avoid shade on any wet or damp sections of the path



- Clear ALL drains by cutting grass and removing silt, debris and any other obstacles.
- It is ESSENTIAL that water runs freely into and along drains during the rainy season

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3 Repair and Maintain the Path Surface

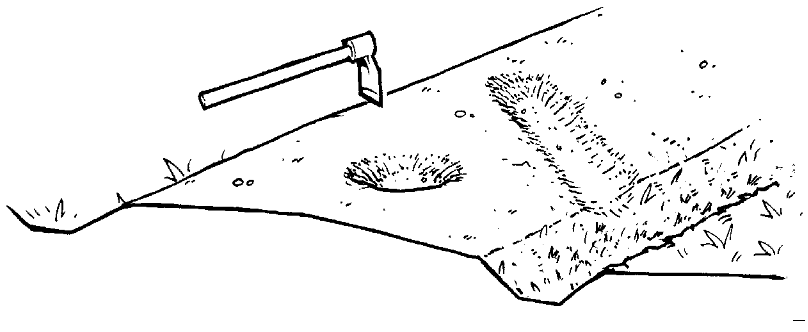
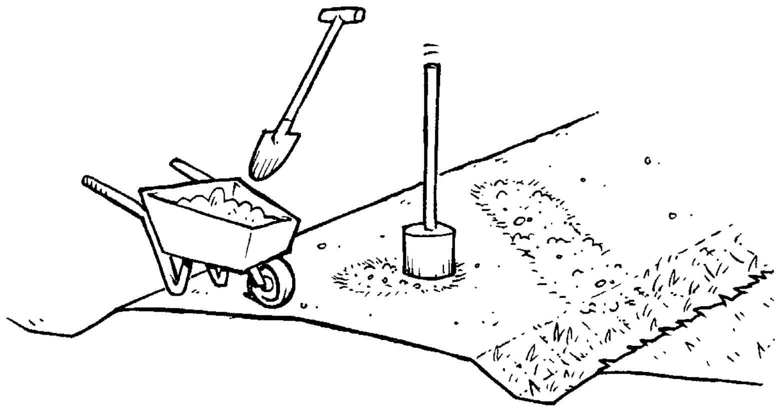
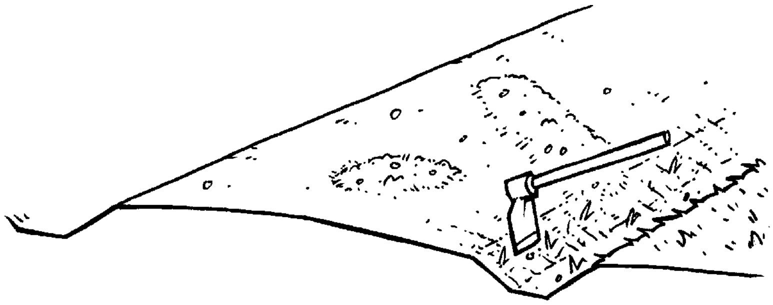
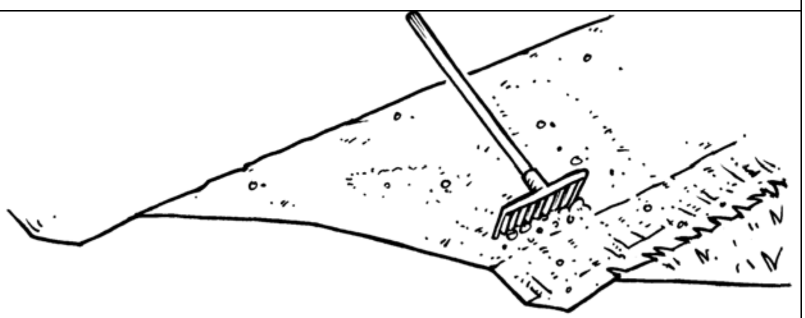
• Clear all debris and obstacles from path • Prepare potholes and erosion gulleys for filling Cut out all loose and crumbly soil until a firm surface is obtained	
• Fill potholes and gulleys with suitable soil and compact Fill with suitable soil, compacting in layers Leave filling slightly above surface to allow for setting	
• Grub edges of path to remove grass and weeds	
• Repair camber of path Loosen edge soil and rake towards centre to reform the camber. Check camber with a profile board Compact loose soil with hand rammer	

Table 5.1: Routine and Periodic Maintenance for Footpaths

Path	Routine Maintenance	Periodic Maintenance
ALL Drains	1. Cut grass and clear bush 2. Remove debris silt etc	Inspect drains for erosion damage and identify problems. Use techniques from Chapter 3 to deal with problem
Scour Checks	1. Remove debris and excess silt (NOT main silt build-up) 2. It is important that there are no gaps through which water can flow: - replace any missing or damaged sticks - replace missing stones	Replace rotting sticks
	1. Clean and remove debris, silt etc 2. Ensure logs are kept in position by proper plugging 3. Fix stones where loose or missing	Replace logs and plugs, if they are rotten or eaten by ants Replace stones that are washed away
Drainage Dip	1. Remove and clean silt or debris	
French Drain	1. Remove debris and silt from the surface	If completely blocked take out the stones clean them and place them back in the trenches
Steps	1. Secure loose logs and plugs 2. Add soil to fill depressions on step surface and compact 3. Fix loose or missing stones on stone steps 4. Reshape side slope to drain away water 5. Check and make safe hand rails	Replace logs and plugs if rotten or eaten by ants Replace stones where washed away Inspect for erosion damage, identify any problems and use appropriate techniques from Chapter 3 to deal with these
Boardwalks	1. Fasten loose cross boards in position 2. Check all joints 3. Fill depressions at approaches	Replace the whole structure if rotten or eaten by ants
Raised Paths	1. Fill any depressions on path surface 2. Check for any erosion damage. If found, improve drainage to overcome problem	Replace the logs if rotten or eaten by ants

Water crossings	Routine Maintenance	Periodic Maintenance
Stepping Stones	1. Secure and replace stones as required 2. Remove any slippery fungus from surface of stones	
Culverts	Clean out culvert including inlet and outlet	Replace the whole structure if rotten or eaten by ants
Footbridge	1. Fasten deck boards in position and replace any damaged boards 2. Check and secure all joints 3. Check and make safe hand rails 4. Fill depressions at approaches	Paint timber with preservative Replace the whole structure if rotten or eaten by ants

5.3 ORGANISATION OF MAINTENANCE

5.3.1 PRIORITY OF MAINTENANCE ACTIVITIES

No matter where the path is located, the overriding priority for routine maintenance is to keep the drainage system working effectively. Blockage of the drainage system is likely to lead to serious damage to the path and surrounds. Therefore prior to and during the rainy season priority must be given to making sure all drains and associated features are working efficiently. During the dry season greater priority will be given to maintenance of the path itself and the surrounds. Table 5.2 summarises the maintenance priorities over the year.

Table 5.2: Priority Rating for Maintenance Activities

SEASON	Priority	ACTIVITY
Before Rains	1	Clean culvert inlets and outlets
	2	Clean mitre drains (off-shoots)
	3	Clean side drains and catch water drains
Rainy Season	1	Inspection and removal of obstacles
	2	Clean culvert inlets and outlets
	3	Clean side drains and catch water drains
	4	Clean mitre drains (off-shoots)
	5	Repair scour checks and side drain erosion
End of Rains	1	Repair erosion gulleys on shoulder, side drains etc
	2	Fill potholes and minor gulleys in the carriageway
	3	Grub edge and reshape carriageway
	4	Cut grass in the side drains
Dry Season	1	Fill potholes and minor gulleys in the carriageway
	2	Grub edge and reshape carriageway
	3	Clear bushes and shrubs
	4	Cut grass in the side drains

5.3.2 ESTIMATE OF WORK INPUTS NEEDED FOR ROUTINE MAINTENANCE

It is difficult to stipulate the frequency of carrying out routine maintenance activities. It is necessary to carry out regular inspections and to use a check list (Figure 5.1 and Table 5.1) to make sure work required is carried out. Feedback should also be sought from users of the path.

The main input is likely to be in the rainy season to keep the drains open and working.

Typical data built up over the years for work inputs to routine maintenance of earth roads is shown in Table 5.3. It is estimated that the input for paths is likely to be about one-third of this (based on a proportionate width) and this therefore gives a guide for estimating the work days needed for routine maintenance of paths.

Table 5.3: Routine Maintenance Inputs per km per year

Activity Description	Task Rate per person per day	Quantity per km/yr		Input W. Days for path
		Road	Path	
Clean Mitre Drains	$3m^3$	60	20	7
Clean side and catch water drains	$3m^3$	72	24	8
Clear Vegetation (medium)	$450m^2$	24,000	8,000	18
Fill potholes and erosion gulleys	$1m^3$	12	4	4
Grub carriageway edges and maintain camber	$350m^2$	6,000	2,000	6
			Total	**43**

This shows that quite a high input of labour is needed for proper routine maintenance of a footpath that keeps the path in good condition. Maintenance of any features such as culverts, steps and water crossings which are part of the path will add to the total.

Assuming that each person is willing to provide 20 to 25 days of voluntary community labour per year, a team of about 2 to 3 persons is needed for routine maintenance of each 1km of the path.

5.3.3 IMPLEMENTATION OF ROUTINE MAINTENANCE

Maintenance of paths and tracks is usually the responsibility of the villages that use them. They may need technical assistance to help with persistent problems.

Paths and tracks fall into 2 categories:

1. Village Paths: used mainly by one village and therefore the responsibility of that village.

2. Route Paths: used by a number of villages. Each village should be responsible for the length of path that falls within their boundaries.

A clear agreement is needed between the villages to define responsibilities and boundaries. This should also include provision of labour to help maintain the most heavily used or difficult sections of the path/track. There may be sections of the footpath which require much more than the average input of labour for maintenance. It is not fair that this extra burden should all fall on the adjacent village. Some help should be provided by other villages using these section of the path.

Village Path Committee

A committee is needed to be responsible for keeping paths and tracks in good condition. This should include both men and women who use the paths regularly.

The committee should identify and plan the work needed. Advice on problem areas should be obtained from the District Works Department. Inputs of labour and materials required should be recommended to the village leadership who will be responsible for organizing these.

Most labour will need to be provided on a voluntary basis. In many communities there is a requirement for members to contribute a number of days per year to community upkeep. There may also be an arrangement for persons who do not wish to participate to pay an equivalent tax that can be used to employ extra labour.

A community tax is needed to pay for materials such as timber, steel and cement. Some specialized tools may also need to be provided.

The maintenance programme needs to be organized around the agricultural cycle but also needs to be carried out when it is most effective. For instance, drains should be kept clear in the rainy season but work on the path surface is unlikely to be effective at this time. This needs to be done as soon as possible after the rains have ended.

Lengthman arrangement

Experience has shown that an effective organisation of routine maintenance is the '*lengthman arrangement'* where a person is made responsible for a specified length of road or path. This allows the person responsible for the maintenance of each section of road/path to be readily identified and any problems sorted out by the supervisor.

This is an appropriate method for organising routine maintenance of footpaths by the community, with sections of paths being allocated to a person or family. The length to be allocated will depend on the total length of path(s) to be maintained and the number of persons/families available to carry out the work. The maximum length per person should not exceed about 0.5km otherwise the time required will be too great and the maintenance may not be properly carried out.

ANNEX 1: PRINCIPLES OF STONE PATH CONSTRUCTION[1]

A1.1 INTRODUCTION

These methods have been used for centuries and in many places to counter path erosion. However, they require skilled technique and great care must be taken. Quality is important, a poorly made path will quickly prove ineffective. It is advisable to practice and learn to adapt these techniques before starting a path repair project.

Every path is unique and the main skill of path builders is to adapt and improvise their techniques for a wide range of circumstances.

Stone paths are mainly needed in hilly areas of medium to high rainfall to counter erosion caused by large run-off of rainwater. Typically they will be needed on slopes over 1 in 4.

It is important to remember that it is not the surface alone, that is being dealt with, but the whole area that the path passes through. A path repair project has two aims:

1 To prepare a suitable path surface
2 Erosion control and re-vegetation of the area around the path

A1.2 PLANNING

This can only be done with the active support of the community. It is important to understand how and why the erosion occurred as this will impact on a proposed solution. It is essential to get extensive feedback from people who have used the path over a long time.

The path should be walked several times, in dry weather, wet weather and most importantly, in very wet weather. It is vital to understand the effects of flow of water and of flood conditions on the path.

Also it is important to know what methods have been used in the past and to find out how effective these have been and what problems have occurred.

Action Plan

Having completed a detailed technical survey of the section of footpath to be improved, dimensioned plans for the work to be carried out and an action plan for implementation should be prepared.

[1] **This annex has been prepared by Andy Carling of Mountain Repair International. Andy is a consultant with wide experience in construction of stone footpaths. For further details see www.sustainabletrails.org or contact 'andy.carling@virgin.net'**

The plans should show:

- the locations and lengths of stone path which are needed
- the drainage layout needed to drain water from the path and to limit the amount of water running onto the path
- where drainage water is to be dispersed
- erosion control and re-vegetation needed around the path

The important issues of the Action Plan are:

Logistics: the key to a successful project is logistics. The action plan should identify where the stone is to be collected and how it is to be transported to site for each section of the path. It must be remembered that large stones may be very heavy, 50kg or more. A safe means of moving the stone must be worked out.

Resources: an estimate of the tools and labour needed - excavation and probably rock-breaking tools will be required. The number of work days that will be needed can be estimated from the guidelines given in Section 2.2.5. A typical rate for laying a stone path is $2m^2$ per day. The requirements for transport of stones will need to be estimated for the local situation and the methods to be used.

Work Programme: based on the labour available, a work schedule should be drawn up with weekly targets.

The action plan should be discussed and agreed with the community.

A1.3 IMPLEMENTATION

Generally, it is best to build the major drains first, starting from the top of the path. This will help to keep the work area dry. Then start the stone sections.

If more than 5 people are working on the path, split them into groups of two or three and give each team a section to build. Each team should be around 10m -15m apart.

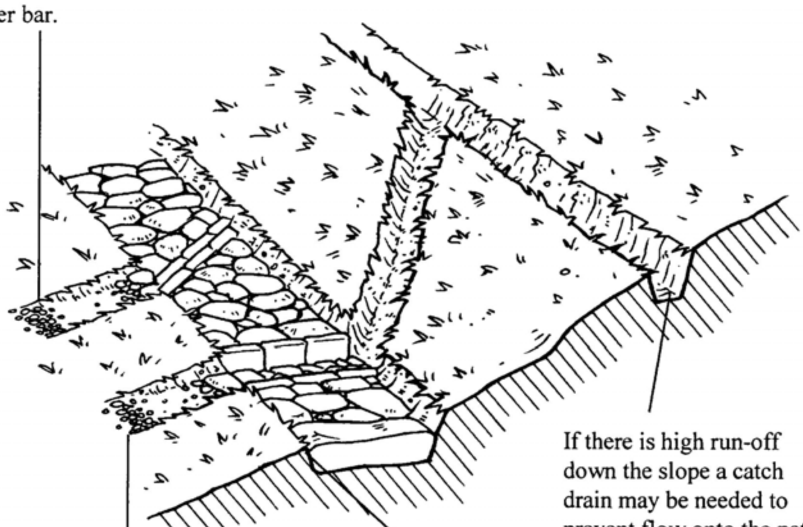
As the stone path is made it should be landscaped. Large eroded areas should be recovered when there are sufficient numbers of workers and the weather is appropriate.

It is important to devise a safe and effective method for transporting the stones to site. This will depend on the terrain and the size of the stones. Possible methods may be – hand to hand along a line of people; stretchers; wheelbarrows (safety ropes may be needed to help with the control and movement of the barrow). A tirfor winch is useful for moving large stones.

A1.4 MAINTENANCE

A new path will require attention for some months, mainly filling in gaps between stone and in drain bottoms. The path should be swept of debris until the path edge has re-vegetated. Drains should be cleared at regular intervals and before heavy rains. It is important to monitor the state of the path to see if any additional work is needed.

Figure A1.1: Typical Features of a Stone Path



Notes: The *water bar* prevents too much water flow along the path.
The *cross drain* carries drainage water across the path.

A1.5 CONSTRUCTION

These are some basic but useful methods. Users are encouraged to improvise and adapt them.

The key to a good path is in selecting good stone. Ideally they have a flat top, large enough to be stepped on comfortably and a depth exceeding 30cm. Use as large stone as possible.

Begin each section by burying a large stone, just below ground level. This will support the weight of the path above and prevent erosion below the path that may undermine the stone path.

Dig a trench as wide as the path for two or three metres uphill. Place the excavated soil on the outside edge of the path. A small bank encourages users to stay on the path.

Place stones in the trench so that the surface is flat and a few cm below ground level. Build the path as a series of horizontal rows, crossing every joint. Each stone should be wedged securely with smaller stones.

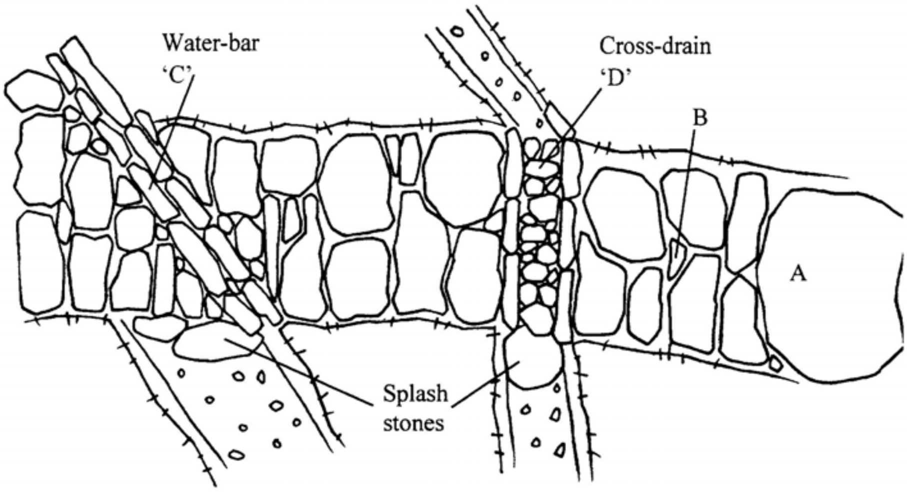
The path should climb at the same angle as the ground. Raise the path by setting the next row a little higher. Avoid edges that may cause a person to trip. However, specific steps can be included at a convenient spacing. The rise of steps should not exceed about 15cm.

When the end of the trench is reached go back and hammer in wedging stones in any gaps to fill them. As the next 2 to 3 m is dug out put some soil on the section that has just been built and work it in until all gaps are filled.

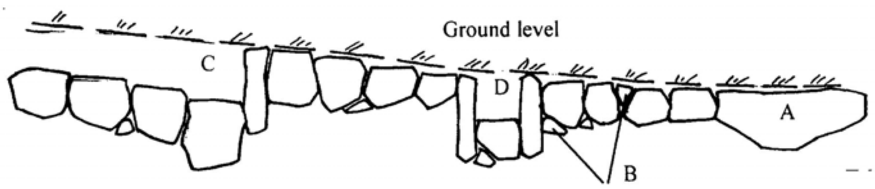
If the stones are level, below ground level and tightly wedged, the construction should be satisfactory and long-lasting.

To avoid erosion damage to the path *water-bars* should be used to control flow of water along the path and *cut-off drains* may be needed to prevent too much water flowing down onto the path. In the latter case *cross*-drains will be needed to carry drainage across the path. Details of construction of stone water-bars and cross-drains are shown on the following pages.

Figure A1.2 : Details of Construction



Plan view looking down on path



Cross-section along centre of path

A: start each 2 to 3m section of path by burying a large stone to support the path above it.

B: use smaller stones as wedges to hold larger stones securely in place.

*S*tone Drain Construction

- Dig a trench to suit the water flow. Place side stones A making sure the stones are vertical and do not stand proud of the path. Surface stones should be at least 40cm deep.

- Use wedging stones to support them.

- Tightly fill the bottom of the drain with stones B

- Place wedging stones to fill in any gaps in the base

- Cover bottom with soil, silt etc and work it into any gaps

- Place splash stone D at the outflow to stop scouring

- It is often a good idea to add an extra 1m of paving at the inlet and outlet to prevent scouring

Minimum Dimensions

A should be 40cm deep

B should be 15cm deep

Drain width 30cm

Drain depth should be 25cm.

Stone Water-bar Construction

- Build at an angle between 45 and 60 degrees to the direction of the path

- Build up to the bar, making sure that the last row of path stones are at the same height as the bar.

- Place an angled line of edge stones B minimum depth 40cm

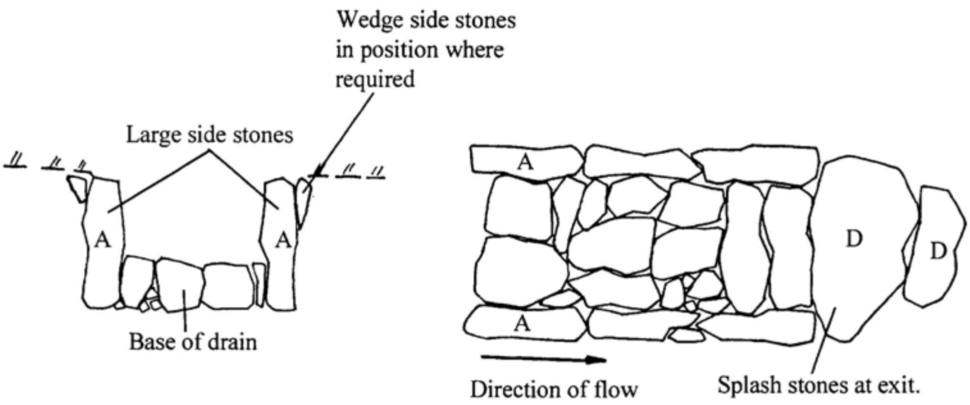
- Place base stones C minimum depth of drain 10cm

- Place splash stone D on the drain exit

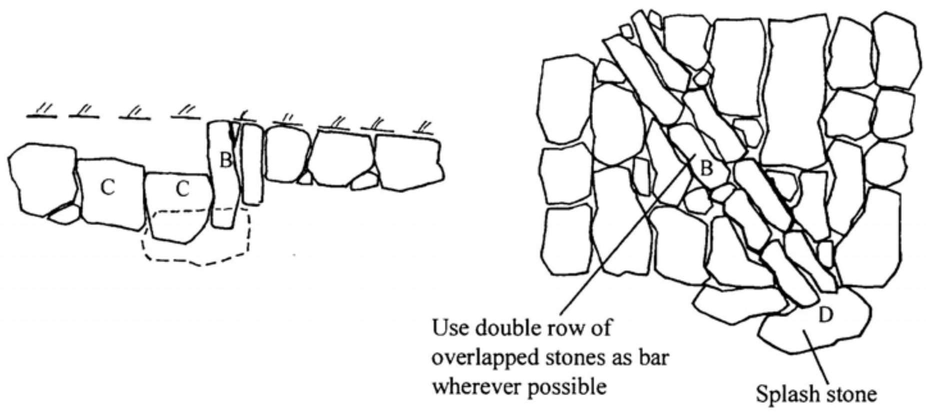
- Wedge the drain tightly

Figure A1.3 Details of Construction

Cross-drain



Water-bar



ANNEX 2: SAMPLES OF AGREEMENTS WITH THE COMMUNITY

Community – Council
Agreement

Village Travel and Transport

Date of Contract: ……………………………………..

Name of Project: ……………………………………..
……………………………………..
……………………………………..

Project Number: ……………………………………..

Name of Village: ……………………………………..

Prepared by:
Checked by:
Approved by:

Please note that further details are to be added

TABLE OF CONTENTS

1. General Agreement

1.1 Introduction

The purpose of this Agreement[2] is to clarify in writing the agreed commitments, conditions and responsibilities of the parties (i.e. the Community and the Council involved in the implementation of a particular Village Travel and Action Plan (VTTAP, see the Appendix).[3]

The Agreement is structured as follows:

Chapter 1 – General Agreement

Chapter 2 – Appendices containing Details of the Agreement:

Appendix A, Facilities and Services provided by the Community

Appendix B, Facilities and Services provided by the Council

Appendix C, Other (e.g. Copy of Village Travel and Transport Action Plan, Detailed Description of the Work, Time Table for Execution of the Work): (please specify)
…………………………………………………………
…………………………………………………………

All pages of the Agreement should be duly filled in, numbered and signed signifying full understanding and approval of all conditions of the Agreement.

[2] The agreement format is of pilot nature i.e. it is expected that as experiences are gained during the implementation of VTTAPs in Rufiji District and that the agreement format will subsequently be adjusted/amended for improvements. Such improvements will then be incorporated in future agreements.

[3] This agreement does not contain a Bills of Quantity nor Arrangement for Payment since no payment will take place between the parties. The agreed Services and Facilities are delivered free of charge by both Parties.

1.2 Signatures

We, the undersigned have decided and agreed that the Work specified in this Agreement shall be carried out in conformity with the terms and conditions, specifications and the prices listed in the documents

Representative of the Community

Name:…………………………………………………………………..

Address: ……………………………………………………………..

Title: ……………………………………………….………………..

Signature: ………………………………….………………………..

Date: ………………………………………………….……………..

Representative of the Council

Name:…………………………………………………………………..

Address: ……………………………………………………………..

Title: ……………………………………………….………………..

Signature: ………………………………….………………………..

Date: ………………………………………………….……………..

Witness No. 1

Name: …………………………………………………….……………

Title: ………………………………………………….……………..

Signature: ……………………………………………….……………..

Date: ………………………………………………….……………..

Witness No. 2

Name: …………………………………………………….……………

Title: ………………………………………………….……………..

Signature: ……………………………………………….……………..

Date: ………………………………………………….……………..

1.3 Description of Work

The key components of the work are:

A. (Component no. 1)

B. (etc.)

C. (etc.)

D. (etc.)

E. (etc.)

F. (etc.)

1.4 Work Commencement, Duration and Time of Completion

Commencement of Work (please specify date below)

(date of commencement)
…………………………………………………………………………………

Duration and Time of Completion of the Work (please specify period and date below)

(duration)
…………………………………………………………………………………

(time of completion)
…………………………………………………………………………………

1.5 General Description of the Parties' Contribution

In brief, the **Community** will provide the services and facilities available locally i.e. in the surrounding area. The details are listed in Appendix A.

Likewise, the **District Council** will provide the services and facilities agreed and not available locally i.e. in the surrounding area. The details are list in Appendix B.

1.6 Disputes

Should an unresolved dispute arise between the Community and District Council in connection with the Agreement such dispute shall be referred for settlement to a person or institution to be agreed between the parties. The agreed person or institution is:
(name of arbitrator)
…………………………………………………………………………………

2. Appendices – Details of Agreement

Appendix A, Facilities and Services provided by the Community

Appendix B, Facilities and Services provided by the Council

Appendix C, Other (e.g. Copy of Village Travel and Transport Action Plan, Detailed Description of the Work, Time Table for Execution of the Work): (please specify)

…………………………………………………….

…………………………………………………….

…………………………………………………….

…………………………………………………….

2.1 Appendix A, Facilities and Services provided by the Community

Item	Description of Facility/Service	No. to be Supplied
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		

2.2 Appendix B, Facilities and Services provided by the Council

Item	Description of Facility/Service	No. to be Supplied
1		
2		
3		
4		
5		
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21		
22		
23		

2.3 Appendix C, Other

The following sub-appendices are attached (Please tick as appropriate):

☐ Copy of Village Travel and Transport Action Plan

☐ Detailed Description of the Work

☐ Agreed Time Table for Execution of the Work

☐ Other:

☐ Other:

☐ Other:

Suggested format of Sub-Appendix C, Detailed Description of the Work

The components and sub-components of the work are:

A. (Component no. 1)

- (sub-component A.1)
- (etc)

B. (etc.)

- (sub-component A.1)
- (etc)

C. (etc.)

- (sub-component A.1)
- (etc)

D. (etc.)

- (sub-component A.1)
- (etc)

E. (etc.)

F. (etc.)

G. (etc.)

Suggested format of Sub-Appendix C, Agreed Time Table for Execution of the Work

Time (week or months) Work Component	1	2	3	4	5	6	7	8	9	10	11	12
A												
B												
C												
D												
E												
F												
G												

ANNEX 3: EXAMPLES OF FOOTPATH FEATURES AND PROBLEMS THAT CAN ARISE DUE TO INADEQUATE MAINTENANCE

The examples in this Annex are taken from a study of footpaths in Makete District in South West Tanzania that was carried out for I.T. Transport in 1996/97[4].

Makete is located on a plateau and the footpaths in the study provide access down the escarpment to a rural centre. The Makete Integrated Rural Transport Programme (MIRTP), 1988 to 1991, identified improvement of footpaths as a major need to improve access from the isolated district.

The improvements were carried out in the period 1989 to 1992 and therefore at the time of the study had been in place for 4 to 6 years. Routine maintenance was carried out in the first year or so, but after this little or no maintenance was carried out. The examples therefore given an indication of the deterioration which can occur in 3 to 5 years without proper routine maintenance.

Traffic surveys carried out in the study recorded up to 600 trips per week on the footpaths. This showed increases from 30 to 60% in traffic levels since the improvement of the paths. This clearly illustrates the benefits to be gained from improving and maintaining rural paths and tracks.

[4] Carried out by Frans Blokhuis and Jan Bijl

ANNEX 4.1 CASE STUDY: MALAWI

1. INTRODUCTION

This case study was carried out for I T Transport by CARE INTERNATIONAL IN MALAWI

The manual was used to prepare a proposal for the work recommended to improve a selected length of footpath. The footpath was selected to cover a number of common problems that occur on paths and tracks. Two particular problems are described in the following pages:

M1. Realignment and improvement of the total length of the footpath

M2. Crossing a marshy area

2. DETAILS OF FOOTPATH

The selected footpath is a 6.8 km link from a village to a rural centre which also passes through two other villages en route to the centre.

The path provides access to a main market, trading centre and hospital. Local sections also provide access to primary schools and a grinding mill.

3. PREPARATION

Community Meeting:

Meetings were held with each community along the path to clarify the following issues:

- The main uses of the path and seasonal variations in traffic
- The main access problems along the path and seasonal effects on these problems
- Ideas on the causes of these problems and possible options for overcoming them

Survey of Path:

The Technical Assistance team together with key informants from the communities walked the length of the footpath to identify the condition of the path and note particular problem areas.

Photographs were taken and notes made to illustrate the improvement work needed

Traffic Survey:

A traffic count was carried out on the path between 6 am and 6 pm on a market day. (this was during the dry season). Ideally counts should be carried out on 2 days, a busy day and average day. Seasonal variations can be assessed from community discussions.

The following data was obtained from the traffic count:

-	Persons walking:	to centre – 415;	from centre – 430;	Total – 845
-	Persons on bicycles:	to centre – 204;	from centre – 193;	Total – 397
-	Oxcarts:	to centre – 7;	from centre – 6;	Total – 13
-	Motorcycles:	to centre – 2;	from centre – 0;	Total – 2
-	Car/4 WD:	to centre – 2;	from centre – 0;	Total – 2

Design Specifications:

Recommended design standards for paths and tracks are shown in Figure 2.2.

The traffic survey shows that 99% of the traffic is persons walking or using bicycles. For these modes a width of 2 m would be adequate. However, the use of oxcarts on the path requires a minimum width of 2.5 m. This allows for only one-way travel of the carts and passing places will need to be provided. This arrangement should be adequate for the small number of carts using the path, particularly as movements will tend to be towards the centre in the morning and from the centre in the afternoon.

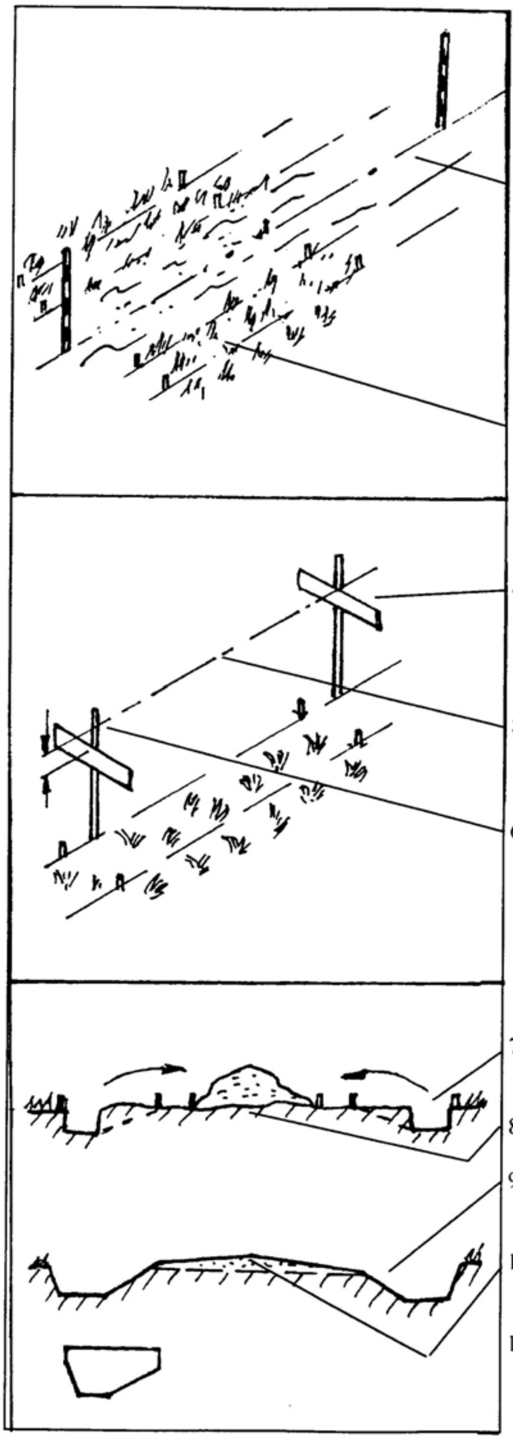
Passing places should be located at least at each end of straight sections and bush should be cleared on the inside of bends to allow a clear view round the bend.

The communities need to give careful consideration to whether cars, 4 WDs etc. should be allowed to use the path. This may depend on whether they provide community services. These vehicles require larger radius bends and may cause damage to the path and structures, necessitating greater maintenance work. To prevent them using the path it may be possible to place barrier posts (at least 20 cm size) at each end of the path that allow the passage of a cart but not a motorised vehicle.

In the case of this footpath, the boardwalk and raised path to cross the marshy area would not be suitable for use by motorised vehicles and therefore barriers should be placed at each end of the path.

M1 REALIGNMENT AND IMPROVEMENT OF PATH

STEPS IN WORK PROGRAMME



STEPS (see 2.2.5)

1. Set out centre line of path with ranging rods. Follow existing alignment but where possible straighten out unnecessary bends.

2. Measure and mark out formation width of 4m. Clear and grub formation width.

3. Cut slots and excavate to level.

4. Use profile boards to set required slope of drain (see Section 3.2.2), about 10 to 20m apart.

5. Use string and spirit level to mark line-level.

6. Set board to height needed to give required slope of drain, so bottom of drain is same depth below board at each rod.

7. Excavate side drains to required depth and longitudinal slope set by profile boards.

8. Throw soil to centre of path.

9. Cut slope of drains to required profile (see Figure 3.3), using Profile Board to check.

10. Spread and compact soil to provide camber on path (Figure 3.3).

11. Set out and excavate mitre drains (see Section 3.3.3).

Evaluation of Quantities

Clearing/ grubbing: From inspection the area to be cleared is on average a 1m strip on each side of the existing path - Length = 6,800m, Width = 1m
Area = 2 x (6,800 x 1.0) = 13,600m^2

Side Drains: Length = 6,800m, Cross section area – 0.09m^2 (see Figure 2.4)
Volume = (6,800 x 0.09 x 2) = 1,224m^3
Add 20% mitre drain = 245m^3
Total volume to excavate = 1,469 m^3

Camber formation: Area = 6800m length x 2.5m width = 17,000m^2

Compaction: Area = 6800m length x 2.5m width = 17,000m^2

Estimation of Work Days (Task rates are taken from Section 2.2.5.)

Activity	Quantity	Task rate/ Person.day	Number of Person.days	Number of Persons	Number of Workdays
Setting Out	6.8km	100m	68	6 (1)	12
Clearing/grubbing	13,600m^2	100m^2	136	50	3
Excavation, Sloping of drains	1,469m^3	3m^3	490	50	10
Camber Formation	17,000m^2	100m^2	170	50	4
Compaction	17,000m^2	100m^2	340 (2)	50	7
Net Totals for workforce (3)			***1,136***	***50***	***24***

Notes:
(1) Carried out by gangleaders and checked by Technical Adviser
(2)It is assumed that it is compacted in 2 layers
(3) Not including setting out

M2 CROSSING MARSHY AREA

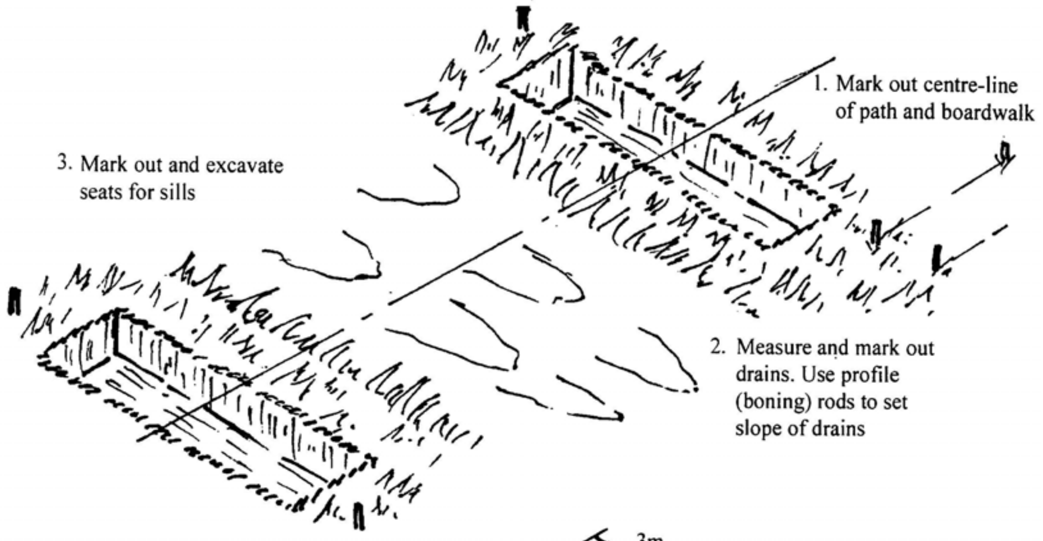
The Plate shows a section where the path passes through a marshy area, crossing a pond through which a stream flows. Rocks in the pond provide difficult access in the dry season but in the rainy season access may be cut off.

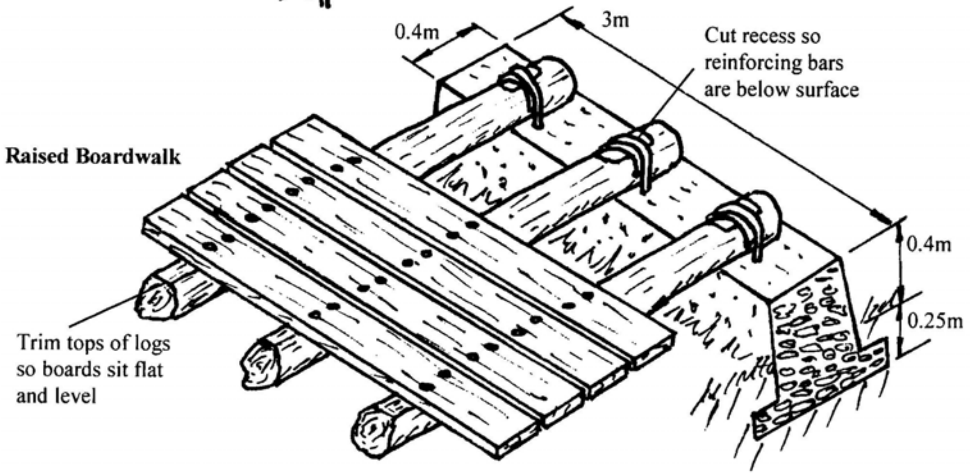
Recommendation: *To provide a boardwalk across the pond and raise the path for 30 m each side of the pond to give all-year round access. The area is flat and the rise of water level in the rainy season is not great. It is judged that the level of the path and boardwalk need to be 0.6 m above the level of the banks.*

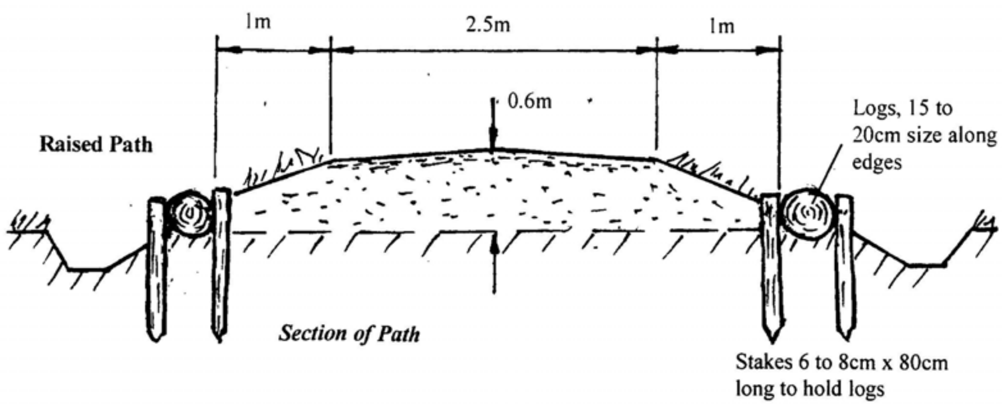
Design Decisions: *Boardwalks* are a relatively simple and low cost method of raising the path the required amount and do not disturb the water flow. The deck may rest on timber or masonry sills. Timber sills are less costly but have a limited life. Masonry sills are the best choice if suitable stones/rocks are available and cement can be afforded. In this case, masonry sills have been selected.

To raise the path 0.6 m, shoulders are needed on each side. A slope of 1:2 (50%) is chosen for stability. For a path width of 2.5 m, a base width of 4.5 m is needed between the retaining poles to allow for the shoulders. The fill from the excavation of the drains only provides a layer of about 10 cm thick on the path. Considerable extra fill is therefore needed. The best solution is to bring in external fill if a suitable gravel soil is available within a reasonable distance. In this case it is available about 200 m away.

Setting Out


1. Mark out centre-line of path and boardwalk
3. Mark out and excavate seats for sills
2. Measure and mark out drains. Use profile (boning) rods to set slope of drains


0.4m
3m
Cut recess so reinforcing bars are below surface
Raised Boardwalk
0.4m
0.25m
Trim tops of logs so boards sit flat and level


1m
2.5m
1m
0.6m
Raised Path
Logs, 15 to 20cm size along edges
Section of Path
Stakes 6 to 8cm x 80cm long to hold logs

Steps in Programme of Work

1. Setting Out:

- Use ranging poles and string to set out the centre-line of the total length of path to be improved – mark with pegs
- For the raised lengths of the path, mark out the edges of the path and drains, taking into account the retaining logs and shoulders – mark with pegs
- Set out the slopes needed for the drains using profile boards, string and spirit level (see previous Section M1)
- Mark out the areas to be excavated for the masonry sills

2. ***Raised Boardwalk:*** (see Section 3.5.2)

- Excavate the seats for the sills, about 25 cm deep
- Cast the sills using stones/rocks and mortar – note the shape and dimensions in the figure. If the base soil is soft and wet cover it with pieces of sacking (geotextile material) or a layer of thin branches
- Cut lengths of steel reinforcing bar, bend the ends at right angles and embed these in the stones and mortar to provide strong anchors for the deck posts
- Fill and compact the soil around the feet of the sills
- Place the deck logs in position and hammer over the ends of the reinforcing bars to hold the logs in position. The bars should fit in grooves cut in the surface of the logs so that the boards lie flat on the logs
- Nail boards 20 to 30 cm wide and 5 cm thick on top of the deck logs. Before nailing, the top surfaces of the logs should be shaved (trimmed) if necessary to make the boards lie level and resting on all 3 logs.

3. ***Raised Path*****:** (see Section 3.5.3)

- Excavate the ditches each side of the path to profiles shown in Figure 3.3. Throw the soil onto the path area
- Lie logs 15 to 20 cm in size along the edges of the path and hold them in position with 6 to 8 cm stakes x at least 70 cm long, hammered well into the ground
- Spread and compact the soil thrown from the ditches. If the soil is wet and muddy it is a good idea to spread a layer of geotextile material or thin branches over the surface before spreading external fill
- Transport external fill from borrow pit, spread and compact in 10 cm layers

Build up path surface to required height and form 8% camber on surface. Grade the shoulders evenly down to the logs and regrass shoulders.

Evaluation of Quantities

Excavation of Drains:

Depth 25cm - Cross section area = 0.12 m^2 (see Figure 2.4)
Total length = 120m ∴ total volume = 0.12 x 120 = 14.4cu.m

Masonry Sill:

Cross section area = 0.45 x 0.52 + 0.75 x 0.12 = 0.33 m^2
Length = 3 m ; volume of 2 = 2 x 3 x 0.33 = 2.0 cu.m

Materials – 2.0cu.m stones/rocks; 0.8cu.m river sand; and 6 bags of cement

Boardwalk:

Treated logs – 3 x 25cm size or 4 x 20cm size, 4m lengths of each

Deck – hardwood planks 5cm thick x 20 to 30cm wide x 3m long -if 22.5cm wide, 17 will be needed

Raised Path:

Fill is needed for the raised path and the shoulders
Cross-section area of path + camber = 0.5 x 2.5 + 0.5 x 0.1 x 2.5 = 1.38m^2
Total length = 60 m ∴ Volume of external fill needed = 82.8cu.m
Add 30% to allow for compaction – Volume = 108cu.m.
Cross-section area of shoulders = 0.5 x 1 x 0.5 x 2 = 0.5m^2
Volume = 30cu.m. – Total volume of fill = 138cu.m.

Treated logs – 15 to 20cm size x 120m total length
Stakes – 6 to 8cm x 80cm long – at least 2 per 3m and 4 per log

Estimation of Work Days

Activity	Quantity	Task rate / Person.day	Number of Person.days
Setting out			2
Collecting materials			10
Raised Boardwalk			
Excavation	1.5 cu.m	1.5 cu.m	1
Constructing sills	2.0 cu.m	1.5 cu.m	2
Constructing deck	1		4
Raised Path			
Excavation of drains	13.2 cu.m	2 cu.m	7
Excavation of gravel	138 cu.m	2.5 cu.m	56
Hauling 200m	138cu.m	3 cu.m	46
Spreading fill	138 cu.m	10 cu.m	14
Compacting fill (6 layers)	150m^2	100 m^2	1.5 x 6 = 9
Total			***151***

Planning

If work involves more than one related activity that goes on at the same time, it is important to match the work rates and number of workers allocated to each task to make sure the work proceeds smoothly without unnecessary hold-ups.

In this case it is planned to transport the fill using 6 oxcarts. Therefore, loading, haulage and unloading must be matched to make sure carts are not kept waiting.

The estimated times for each activity from Section 2.2.5 are:

Loading – 10 cu.m per day = 1.6cu.m per hour; time for 1 person to load cart (0.4 cu.m) = 15 minutes

Haulage – 3 km/hr = 50m per minute; time for 200m = 4 minutes; assume 10 minutes for round (2-way) trip

Unloading – 12 cu.m per day = 12 minutes per cart

Total time for round trip of cart including loading and unloading = 37 minutes. Each cart will make 8 trips per day.

Therefore each loader and unloader can service 2 carts with reasonable rest breaks and 3 loaders and 3 unloaders will be needed for the 6 carts.19 cu.m will be transported per day, requiring 8 days to complete the work.

The work rate for *spreading* is 10 cu.m per day and for *compacting*, 100m^2 x 0.1m = 10 cu.m per day. Therefore 2 persons will be needed for each of these tasks to match the haulage of fill.

ANNEX 4.2. CASE STUDY: SRI LANKA

1. INTRODUCTION

This case study was carried out for I T Transport by ITDG SOUTH ASIA (IT Sri Lanka)

The manual was used to prepare a proposal for the work recommended to improve a selected length of footpath. The footpath was selected to cover a number of common problems that occur on paths and tracks. One problem is described in the following pages:

SL1. Improvement of an embankment path

2. DETAILS OF FOOTPATH

The footpath provides access from a village in the Kandy District to a bitumen road. Kandy is a mountainous area with high annual rainfall.

The length of the footpath is 890 m. It provides access for the village population of 144 to work places, water supply, bathing places and to a shop on the bitumen road.

3. PREPARATION

Similar steps in the preparation to design the improvements to the path were carried out as in Annex 4.1 – community meeting, survey of path and traffic survey. The meeting and survey identified a number of problems along the path such as flooding of an embankment path, steep slippery slopes and poor cross-drainage of the path.

The only vehicles owned in the village are1 bicycle and 1 motorcycle so that almost all traffic on the path is pedestrian. The number of walking trips per day varies between 100 and 120.

4. DESIGN SPECIFICATIONS

Figure 2.2 recommends that for a traffic level of 100 per day, a 2-way path of 1.2 m wide is needed. However, the path passes through private farming land and in places the total width, including drains, should be restricted to 2 m to avoid disputes with landowners. Therefore a path width of 1 m is chosen. Where there is a width restriction special sections will need to be designed for any improvements that are needed.

SL 1. IMPROVEMENT OF A PATH ON AN EMBANKMENT

The Plate shows a 70 m long stretch of footpath that passes along an embankment bordering a paddy field. The path is narrow and overgrown with grass. The side drain is partly blocked and regularly overflows in the rainy season, flooding the path. This leaves the path in a muddy and slippery condition. A number of falls have occurred along the path. The land to the right of the drain is privately owned and there is little scope for extending the overall width of the path.

Recommendation: *Import gravel/soil to raise the level of the footpath by 30 cm and provide a non-slippery surface.*

Clean out the side drain and increase the depth to 30 cm. Because of the lack of space to provide an adequate slope from the path to the drain, line the inner edge of the drain with rocks to prevent erosion.

Cut a 1:1 slope from the path down to the paddy field and regrass to minimise erosion.

STEPS IN WORK PROGRAMME

1 Clearing and grubbing:

- Clear bush along the drain
- Remove grass and organic material from path area

2 Setting out:

- Use ranging poles and string to set out line of path
- Use strings and pegs to mark out the outline of improved path section as shown in figure
- Use boning (profile) rods to set up level and the required slope of the drain (see A4.1)

3 Excavation:

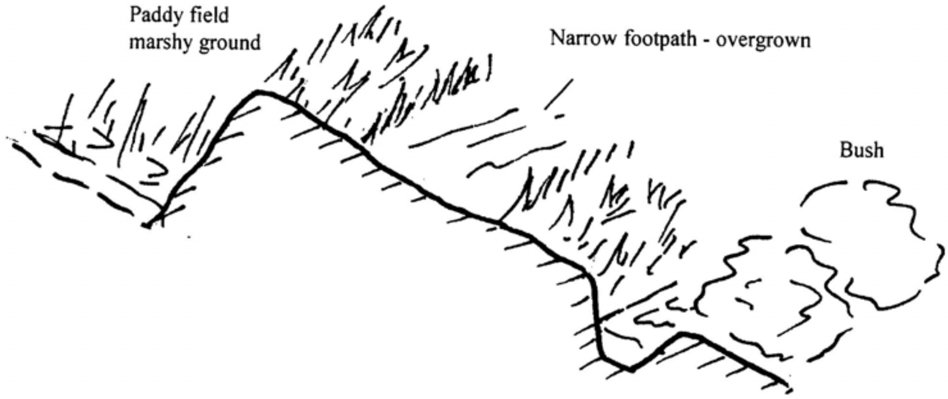
- Clean out the drain to the required depth and profile
- Cut the slopes on the shoulders on each side of the path

4 Build up path surface:

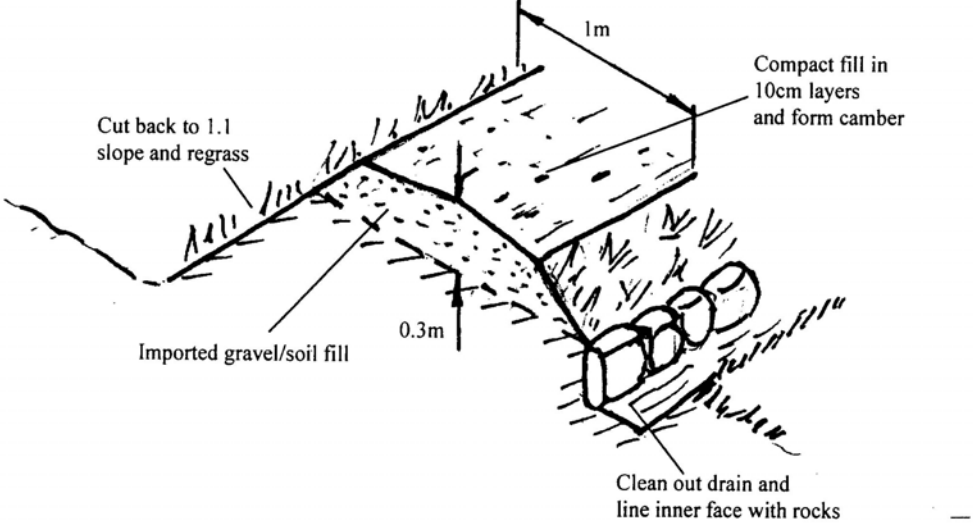
- Excavate fill and transport to site using wheelbarrows
- Spread fill and compact in 10 cm layers using hand rammers. Form camber on path

5 Construct stone lining for drain:

Improvement of Footpath on Embankment



Section Across Existing Footpath



Section Across Improved Footpath

Evaluation of quantities

Clearing and grubbing: Strip 1.5m wide x 70m long gives area = 105m^2

Excavation: Drain - Drain size to be 25 x 25cm – assume 50% has to be excavated
Cross-section area = 0.5 x 0.25 x 0.25 = 0.033m^2

Excavation for stone lining – assume 6cm thick = 0.06 x 0.25 = 0.015m^2. Therefore Total area = 0.048m^2

Excavation volume = 0.048 x 70 = 3.5 cu.m

Sloping - Depth to paddy field = 1m, therefore area = 0.5 x 1 x 1 =0.5m^2

Volume = 0.5 x 70 = 35m^2

Total volume = 38.5cu.m

Fill: Height of path raised 0.26m
Upper width = 1m, lower width = 1.52m (1:1 slope each side)
Cross-section area = 0.26 x 0.5(1 + 1.52) = 0.33m^2

Cross-section of chamfer = 0.5 x 0.04 x 1 = 0.02m^2

Volume of fill = 70(0.33 + 0.02) = 24.5 cu.m
Add 30 % for compaction = 32 cu.m

Stone lining: Volume = 0.06 x 0.25 x70 = 1.05 cu.m

Estimation of work days

Activity	**Quantity**	**Unit**	**Task rate/ Person day**	**Number of Person.days**
Setting out				2
Clearing and grubbing	105	m^2	50	2
Excavation	38.5	cu.m	3	13
Excavation of gravel	32	cu.m	2	16
Haulage (100m)	32	cu.m	3	11
Spread fill material	32	cu.m	10	3
Compact fill (3 layers)	70	m^2	100	2
Collect stone/rock	1.05	cu.m	1	1
Break stone/rock	1.05	cu.m	0.4	3
Lay stone lining	1.05	cu.m	1	1
Total work days				***54***

ANNEX 5

REFERENCES AND SOURCES OF FURTHER INFORMATION

ANNEX 5: REFERENCES AND SOURCES OF FURTHER INFORMATION

A5.1 REFERENCES

There is a considerable body of reference information now available on the improvement and maintenance of rural roads. This section presents a selection of that which is considered most relevant and appropriate for technical staff at the local level and which should be relatively easy to obtain.

A5.1.1 TRAINING MANUALS

Roads departments in many countries produce training manuals for their staff. The following should be reasonably easy to obtain.

MINISTRY OF WORKS, TANZANIA (1996): Training Manual on Construction and Maintenance of Footpaths
Prepared by Pal Saetrum for the Mbeya Appropriate Technology Training Institute, Tanzania

Compiled from ILO reports and documents on the Makete Integrated Rural Transport Project, including – 'Manual on Improvement and Maintenance of Paths' by K. Selvarasa. The manual has been used as one of the sources for the present manual and contains little additional information

ILO(1994): Gangleader Course Technical Manual: Malawi
Prepared by Tint Swe for Pilot Integrated Rural Transport Project, Malawi
Available from : Malawi Rural Travel and Transport Programme, P O Box 265, Lilongwe, Malawi

A comprehensive manual on the improvement and maintenance of earth roads and paths that presents technical detail and methods of implementation in simple and well illustrated terms. The manual is useful for providing details of methods and procedures to be used.

P. HARTMANN (1991): Road Projects Manggarai, Indonesia – Labour-based Road Construction
Published by SKAT (Swiss Centre for Appropriate Technology), St. Gallen, Switzerland.

The manual deals with earth roads. It contains limited technical information but is useful in providing good, clear photographs of road features and work methods.

A5.1.2 TECHNICAL MANUALS

Roads departments in many countries produce their own design and technical manuals as a reference source for their staff. Technical manuals contain detailed practical information on methods and techniques of labour-based work, particularly setting out, and are therefore a useful reference source to support the present manual. Two good examples which are readily available are as follows.

MINISTRY OF WORKS, LESOTHO (1996): Technical Manual for Low-volume Roads Upgraded and Constructed Using Labour-based Methods.

Available from ILO-ASIST Information Services, Ref. No. 28141

MINISTRY OF PUBLIC WORKS, KENYA (1992): Technical Manual Volume 1.

Available from Roads Department, Ministry of Public Works, P.O. Box 30260 Nairobi, Kenya.
Also available from ILO-ASIST Information Services, Ref.no. 27298

A5.1.3 REFERENCE BOOKS AND ARTICLES

The following books and articles give good back-up support to the present manual through providing more detailed information on labour-based methods and techniques.

J. HINDSON (1983): Earth Roads: Their Construction and Maintenance
Available from ILO-ASIST Information Services, Ref. no. 01593

This technical manual provides a simple description of road planning, construction and maintenance for non-engineers. In particular it emphasises methods for achieving effective maintenance.

Claes-Axel ANDERSSON, Andreas BEUSCH and Derek MILES (1996): Road Maintenance and Regravelling using Labour-based Methods – Handbook
Intermediate Technology Publications, London

This textbook provides a useful overall coverage of labour-based work, including tools and equipment. It has been written for the owners and managers of small contractor firms and therefore has sections on costing, bidding and managing the labour force.

The following two World Bank articles give a good overview of rural infrastructure and access issues and are particularly useful for showing the use of geotextile materials in protecting structures and the use of natural methods (deep rooted plants) for stabilising steep slopes.

WORLD BANK (2001): Design and Appraisal of Rural Transport Infrastructure.
Jerry Lebo and Dieter Schelling, World Bank Technical Paper No. 496, World Bank, Washington

WORLD BANK (2001): Rural Transport Infrastructure: Guidelines for Community-based Development Projects.
Obtainable from World Bank, Washington – Actual reference details not known

This has greater detail on the design and costing of rural infrastructure than the above paper. It has useful information on the design of bridge abutments and the use of geotextile materials to protect the abutments against erosion.

A5.1.4 COMMUNITY PARTICIPATION

The following two publications provide more detailed information on community participation in infrastructure improvement and maintenance

PETER WINKELMAN (1999): Self-Help for Road Construction: When it Applies – How can it be Encouraged and Supported
Available from INTERCOOPERATION, CH-3001 Bern, Switzerland

This book provides guidelines based on experience from East Indonesia and other countries in the construction of village access roads.

I T TRANSPORT LTD. (1999): Community Participation in Road Maintenance – Guidelines for Planners and Engineers
Available from I T Transport Ltd., The Old Power Station, Ardington, Wantage,
Oxon OX12 8QJ, UK

This manual is based on experience from three countries, Kenya, Tanzania and Uganda

5.2 SOURCES OF FURTHER INFORMATION

The following organisations are useful sources of further information:

ILO-ASIST INFORMATION SERVICES
P.O.Box 210, Harare, Zimbabwe
Email: assist@ilosamat.org.zw

ILO-ASIST has an extensive data-base for responding to technical enquiries. It also has a good range of publications for sale, some of which have been listed above.

THE WORLD BANK
1818 H Street, NW, Washington, DC, 20433 USA
Also has local offices in many countries

INTERNATIONAL FORUM FOR RURAL TRANSPORT DEVELOPMENT
IFRTD Secretariat, 2 Spitfire Studios, 63-71 Collier Street, London N1 9BE, UK

Email: ifrtd@ifrtd.org

IFRTD is particularly strong on networking and can often identify individuals or organisations that can provide further information on rural transport issues. It provides a service for responding to enquiries.

TRANSPORT RESEARCH LABORATORY
Old Wokingham Road, Crowthorne, Berkshire, RG45 6AU, UK
Email: international_enquiries@trl.co.uk

Has an extensive library and data-base on transport issues and also provides training courses relating to rural infrastructure

INTERMEDIATE TECHNOLOGY PUBLICATIONS
103-105 Southampton Row, London WC1 4HL, UK
Email: itpubs@itpubs.org.uk

Provides a mail-order service for books which includes books published by SKAT (Swiss Centre for Development Co-operation in Technology and Management)

A5.3 INTERNET AND WEB SITES

The Internet is becoming increasingly important in dissemination of information and a rapidly increasing volume of useful information can be downloaded from a number of web-sites. The following are considered to be among the most relevant to rural infrastructure.

ILO-ASIST: www.ilo.org/asist

WORLD BANK: www.worldbank.org

INTERNATIONAL FORUM FOR RURAL TRANSPORT DEVELOPMENT: www.ifrtd.org

TRANSPORT RESEARCH LABORATORY: www.trl.co.uk

DEPARTMENT FOR INTERNATIONAL DEVELOPMENT (DFID), UK Government
www.transport-links.org (password – *connect)*

WORLD ROAD ASSOCIATION (AIPCR/PIARC)
www.piarc.org

ANNEX 1

PRINCIPLES OF STONE PATH CONSTRUCTION

ANNEX 2

SAMPLES OF AGREEMENTS WITH THE COMMUNITY

ANNEX3

EXAMPLES OF FOOTPATH FEATURES AND PROBLEMS THAT CAN ARISE DUE TO INADEQUATE MAINTENANCE

ANNEX 4

CASE STUDIES