

INTERNATIONAL ROAD MAINTENANCE HANDBOOK



Volume I

Maintenance of
Roadside Areas and
Drainage

AIPCR



PIARC

INTERNATIONAL ROAD MAINTENANCE HANDBOOK

PRACTICAL GUIDELINES FOR
RURAL ROAD MAINTENANCE

Volume I of IV

**Roadside Areas
and Drainage**

Financed and coordinated by



Revised *by* R C Petts of **Intech Associates, UK**
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as a development of the UN **ECA** handbooks prepared by
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FOREWORD

The road transport network of any country plays a vital role in its economy, and the physical condition of its infrastructure is critical. Without adequate and timely maintenance, highways and rural roads alike inexorably deteriorate, leading to higher vehicle operating costs, increased numbers of accidents, and reduced reliability of transport services. When repair work can no longer be delayed it will often involve extensive rehabilitation, and even reconstruction, costing many times more than simpler maintenance treatment carried out earlier. The need to protect the existing network and keep it in good condition is paramount, often taking precedence over new investment.

PIARC has been in the forefront in promoting this message and in drawing attention to the dangers of neglect. The matter has become increasingly important in recent years for all the highways of the world, but especially so for those in developing countries where there is constant pressure on slender budgets and, in many, an urgent need to cater for growing traffic loads and volumes.

In the late 1970's, the aid ministries of France, the Federal Republic of Germany and the United Kingdom joined forces to produce a "Road Maintenance Handbook" for maintenance foremen and workers in Africa. Published in 1982 under the auspices of the Economic Commission for Africa, the three volumes - in French and English - soon became widely known and used. By the end of the decade their use had spread far beyond Africa, and their straightforward instructions were being used for training purposes as well as for

FOREWORD continued

on-the-job guidance in many countries. The need to reprint provided the opportunity to review the contents in the light of experience and make them more suitable for the wider audience now commanded. PIARC's Committee on Technology Transfer and Development, formerly the Committee on Roads in Developing Regions, undertook to help with this review, which was generously funded by the UK Overseas Development Administration. A sub-committee was established, embracing the three original donor countries, other developed and developing countries, and the World Bank. Although much of the original text has been retained, the new handbooks incorporate more information on labour and tractor-based techniques, and on the development of manpower management and the all-important question of safety at work. The range of maintenance problems addressed has been extended to strengthen their international appeal.

The past ten years have seen major reforms in the general thrust of maintenance policy and in its organisation, management and execution. These changes will continue, and PIARC will play its part along with other institutions in encouraging the process and pressing for further progress. Only a full appreciation of maintenance at the highest levels of policy-making and financial planning can ensure success. But these handbooks have a humbler task-to ensure that the men and women at the operational level are suitably skilled and trained and are using the appropriate tools and techniques, and have interest and motivation in their work.

FOREWORD continued

PIARC has been proud to nurture this project to the point where the new handbooks are available, but its involvement will reach far beyond that. It will provide the necessary international framework within which the handbooks can be translated and printed in many languages. Its worldwide membership of key figures in the national provision and management of highways will assist with their dissemination, ensuring that they find their way into the most appropriate hands in both the public and private sectors. Collectively, these hands will play a fundamental part in sustaining the vital asset which our roadway networks truly represent.

A handwritten signature in black ink, appearing to read 'Victor J Mahbub', with a long horizontal line extending to the right.

Victor J Mahbub,
President of PIARC.

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INTRODUCTION

THE HANDBOOK

This is a guide for the **maintenance foreman or supervisor** assigned to bitumen or unpaved roads in tropical and moderate climates. The objective of the HANDBOOK is to assist him in all aspects of his work whether carried out by direct labour or by contract. Its pocket format enables the volume relevant to the day's work to be easily carried and consulted on site. The HANDBOOK should be his ready reference book. The text is concise and well illustrated. A quick reference should be all that is necessary.

This HANDBOOK does not include a course of study or discuss underlying causes of defects. Inspections, material sources, specifications and testing are also outside its scope. Furthermore it is sufficient here to remind the foreman that his plant and vehicles should be well maintained without telling him how to do it.

Even though the HANDBOOK is intended for use by the maintenance foreman, it will also be useful reading for the engineer or senior supervisor. This will make him more conscious of his duties towards the foreman and enable him to ensure that the maximum benefit is obtained from the HANDBOOK. Each supervisor must understand his responsibility and the part he has to play.

The HANDBOOK can also be used in training centres. With the assistance of country-specific supplementary information, photographic slides, models, and other supporting material, it will be a valuable tool for the trainer and can be distributed to students.

Road maintenance requires a range of organisational and technical skills and the work on roads in use by traffic makes the work potentially hazardous to both the workmen and road users.

It is therefore **essential** that appropriate formal and on-the-job training is given to each category of personnel involved in road maintenance activities to achieve efficient and safe operations.

The foreman usually has an important role in the initial and ongoing training of personnel.

Roads are an enormous national investment and require maintenance to keep them in a satisfactory condition and ensure safe passage at an appropriate speed and with low road user costs.

Late or insufficient maintenance will increase the ultimate repair costs and raise road user costs and inconvenience, and reduce safety.

Road Maintenance is therefore an essential function and should be carried out on a timely basis.

There is a diversity of maintenance activities, the class and type of the road, the cross section to be maintained, the defects recognised, and the resources available. However the general methods proposed here for each activity (with some exceptions) are given under the following headings:

- The task
- Defects
- Resources
- Maintenance method

Where appropriate options are shown for carrying out the work by:

- I) Heavy Equipment,
- ii) Tractor based methods, or
- iii) Labour based methods.

The decision on which method to be used should be made by the engineer or senior supervisor based on considerations of resources available, cost, policy etc.

Maintenance operations are usually grouped in each country according to planning, organisational and funding arrangements. They can normally be categorised as either ROUTINE or PERIODIC.

For the purposes of this HANDBOOK the following grouping is used.

ROUTINE: Operations required to be carried out once or more per year on a section of road. These operations are typically small scale or simple, but widely dispersed, and require skilled or un-skilled manpower. The need for these can, to a degree, be estimated and planned and can sometimes be carried out on a regular basis.

PERIODIC: Operations that are occasionally required on a section of road after a period of a number of years. They are normally large scale and require specialist equipment and skilled resources. These operations are costly and require specific identification and planning. In this

handbook **periodic** also includes certain Improvement works such as thin bituminous overlays.

From time to time urgent or emergency works of any nature may be required and these are dealt with as the need arises.

The HANDBOOK consists of 4 separate volumes:

VOLUME I - MAINTENANCE OF ROADSIDE AREAS AND DRAINAGE

PART A - List of Terms
PART B - Works Management and Safety
PART C - Roadside Areas
PART D - Drainage
General Index

VOLUME II- MAINTENANCE OF UNPAVED ROADS

PART A - Grading
PART B - Labour Based Reshaping
PART C - Dragging
PART D - Patching
PART E - Regravelling (Mechanised)
PART F - Regravelling (Labour and Tractors)

VOLUME III- MAINTENANCE OF PAVED ROADS

PART A - General Repairs
PART B - Surface Dressing (Mechanised)
PART C - Resealing Options
PART D - Thin Overlays

VOLUME IV - MAINTENANCE OF STRUCTURES AND TRAFFIC CONTROL DEVICES

PART A - Bridges

PART B - Traffic Control Devices

VOLUME I

PART A - LIST OF TERMS

This volume provides a List of Terms used in the Handbook and an Index covering all of the four volumes.

PART B - WORKS MANAGEMENT AND SAFETY

General guidelines are provided regarding management and safety of the maintenance operations.

This volume also describes the maintenance of roadside areas and drainage. Although generally straight forward these operations are often neglected. They are, however, important and have the following objectives:

- To minimise the safety risk to road users due to poor shoulders and slopes, poor visibility, grazing animals or fire hazard etc.
- To ensure the stability of the road foundations.
- To ensure that all rain and ground water is directed away from the road, and does not endanger its strength or stability.

PART C - ROADSIDE AREAS

Routine and Periodic Maintenance activities are described which keep the roadside areas in their intended and stable condition, and keep vegetation under control.

Most of the tasks require labour, although some may be carried out by mechanised methods if the equipment is available.

PART D - DRAINAGE

The drainage system is the most important component of a highway or rural road, even in locations with only occasional rainfall. The Routine Maintenance of the drainage system of ditches, pipe drains, culverts and drifts is essential to preserve the road structure and running surface. Most of the activities can be carried out by labour methods.

NOTE: In many countries women carry out road maintenance tasks and supervisory duties. The use of male descriptions and diagrams in this handbook is for convenience only. The guidelines are applicable whether the work is carried out or supervised by men or women.

Part A

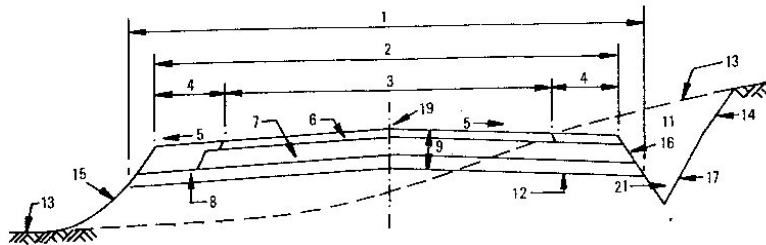
LIST OF TERMS

NOTE: ROAD CROSS SECTION, DRAINAGE

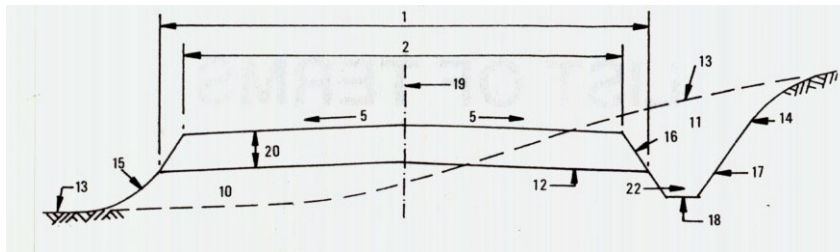
FEATURES AND OTHER TERMS ARE INDICATED IN THE TEXT OF EACH VOLUME BY AN ASTERISK (*)
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PART A-LIST OF TERMS

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PAVED ROAD SECTION



UNPAVED ROAD SECTION

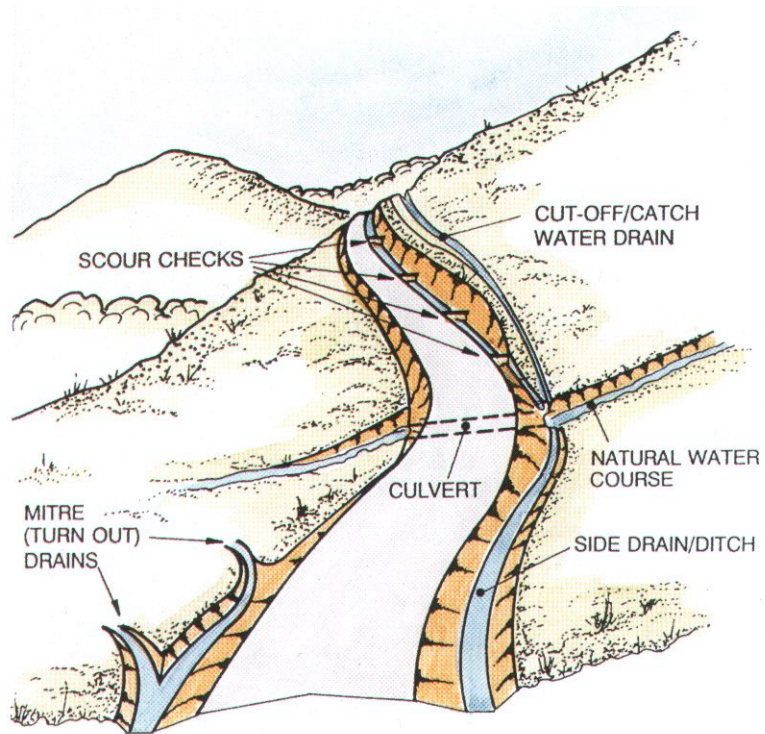
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- | | |
|---------------------------------|--|
| 1. SUBGRADE | 13. ORIGINAL GROUND LEVEL |
| 2. ROADWAY | 14. CUTTING SLOPE |
| 3. CARRIAGEWAY | 15. EMBANKMENT SLOPE |
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| 9. PAVEMENT | 21. V-DITCH |
| 10. EMBANKMENT | 22. TRAPEZOIDAL DITCH |
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| 12. SUBGRADE SURFACE /FORMATION | |

NOTE: Ditch shape according to conditions and maintenance method

PART A - LIST OF TERMS

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PART A- LIST OF TERMS

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PART A - LIST OF TERMS

GENERAL TERMS

Paved Road

For the purpose of this handbook a paved road is a road with a bituminous surfacing.

Unpaved Road

For the purpose of this handbook an unpaved road is a road with a soil or gravel surface.

COMPONENTS OF THE HIGHWAY

Blinding

- a) A layer of lean concrete, usually 5 to 10 cm thick, placed on soil to seal it and provide a clean and level working surface to build the foundations of a wall, or any other structure.
- b) An application of fine material e.g. sand, to fill voids in the surface of a pavement or earthworks layer.

Bridge

A structure usually with a span of 5 metres or more, providing a means of crossing above water, a railway or another obstruction, whether natural or artificial. A bridge consists of abutments, deck and sometimes wingwalls and piers.

Camber

The road surface is normally shaped to fall away from the centre line to either side. The camber is necessary to shed rain water and reduce the risk of passing vehicles colliding. The slope of the camber is called the crossfall. On sharp bends the road surface should fall directly from the outside of the bend to the inside.

PART A - LIST OF TERMS

Carriageway

The road pavement or bridge deck surface on which vehicles travel.

Causeway or Vented Drift

Low level structure constructed across streams or rivers with openings to permit water to pass below road level. The causeway may become submerged in flood conditions.

Coffer Dam

A temporary dam built above the ground to give access to an area which is normally, or has a risk of being, submerged or waterlogged. Cofferdams may be constructed of soil, sandbags or sheetpiles.

Crown

The highest point of the cross section of the road carriageway, usually the centre line.

Culvert

A structure allowing water to flow under the road and having an open span of normally between 0.5 and about 5 metres. The opening may be round, rectangular or arched. The invert, walls and soffit often form an integral unit.

PART A- LIST OF TERMS

Cut (Cutting)

Excavation in natural ground usually with graded slopes.

Deck

The part of a bridge that spans between abutments or pier supports, and carries the road traffic.

Drift or Ford

A stream or river crossing at bed level over which the stream or river water can flow.

Embankment

Constructed earthworks below the pavement raising the road above the surrounding natural ground level.

Formation

The shaped surface of the earthworks, or subgrade, before constructing the pavement layers.

Layby

An area adjacent to the road for the temporary parking of vehicles.

Margins

The right of way or land area maintained or owned by the road authority.

Parapet

The protective edge, barrier, wall or railing at the edge of a bridge deck.

Pavement

The constructed layers of the road on which the vehicles travel.

Roadbase and Subbase

Pavement courses between surfacing and subgrade.

Roadway

The portion of a highway, including shoulders, for vehicular use.

Scuppers

Drainage pipes or outlets in a bridge deck.

PART A- LIST OF TERMS

Shoulder

Paved or unpaved part of the highway next to the outer edge of the pavement. The shoulder provides side support for the pavement and allows vehicles to stop or pass in an emergency.

Slope

A natural or artificially constructed soil surface at an angle to the horizontal.

Stringer

Longitudinal beam in a bridge deck or structure.

Subgrade

Upper layer of the natural or imported soil (free of unsuitable material) which supports the pavement.

Surfacing

Top layer of the pavement. Consists of wearing course, and sometimes a base course or binder course.

Surface Treatment

Construction of a protective surface layer e.g. by spray application of a bituminous or tar binder, blinded with coated or uncoated aggregate.

PART A - LIST OF TERMS

Traffic Lane

The portion of the carriageway defined by road markings for the movement of a single line of vehicles.

Transverse Joint

Joint normal to, or at an angle to, the road centre line.

Transverse Joint Taper

Slope or ramp of premix material at the end of a freshly laid premix course.

Wingwall

Retaining wall at a bridge abutment to retain and protect the embankment fill behind the abutment.

DEFECTS

Bleeding

Excess binder on the surface of the pavement.

Block Cracking

Interconnected cracks forming a series of large polygons usually with sharp corners or angles.

Cracking

Narrow breaks in a surfacing or pavement material caused by overloading, fatigue or weakness of the material.

Crazing (Alligator Cracks)

Interconnecting network of cracks in the road surfacing.

Depression

Localised low areas of limited size in the pavement surface or in any other surface.

Edge Cracking

Longitudinal cracking near the edge of the pavement.

Excess Aggregate

Aggregate particles not coated with binder after application of binder.

Fretting

The loss of chippings from the surface seal or premix layer due to poor bond between the aggregate and the seal or binder.

Glazing

Wear or embedment of chippings in the surfacing giving a smooth, shiny appearance.

Loss of Surface Aggregate

Removal of aggregate from a surface dressing, or from surfacings with coated aggregate.

Scour

Erosion of a channel bed area by water in motion, producing a deepening or widening of the channel.

Slip

Slope material sliding downhill because of instability, water penetration or flow.

PART A- LIST OF TERMS

Streaking

Alternate lean and heavy lines of bitumen running parallel to the pavement centre line, caused by blocked or incorrectly set spray nozzles.

Stripping (Ravelling)

The loss of surface seal from the pavement due to poor bond between the seal and the lower pavement layer.

DRAINAGE

Apron

The flat invert of the culvert inlet or outlet.

Basin

A structure at a culvert inlet or outlet to contain turbulence and prevent erosion.

Berm

A low ridge or bund of soil to collect or redirect surface water

Cascade

A drainage channel with a series of steps, sometimes with intermediate silt traps or ponds, to take water down a steep slope.

Catchpit

A manhole or open structure with a sump to collect silt.

Chute

An inclined pipe, drain or channel constructed in or on a slope.

Counterfort Drain

A drain running down a slope and excavated into it. The excavation is partly or completely filled with free draining material to allow ground water to escape.

Cut-off/Catchwater Drain

A ditch constructed uphill from a cutting face to intercept surface water flowing towards the road.

Debris Rack or Grill

Grill, grid or post structure located near a culvert entrance to hold back floating debris too large to pass through the culvert.

Ditch (Drain)

A long narrow excavation designed or intended to collect and drain off surface water.

Drainage

Interception and removal of ground water and surface water by artificial or natural means.

Drainage Pipe

An underground pipe to carry water.

Flow Spreader

A structure designed to disperse the flow at the outfall of a ditch or drain to minimise the risk of erosion down stream.

Invert

The lowest point of the internal cross-section of a ditch or culvert

Manhole

Accessible pit with a cover forming part of the drainage system and permitting inspection and maintenance of underground drainage pipes.

Mitre Drain

Or Turn Out Drain, leads water away from the Side Drains to the adjoining land.

Outfall

Discharge end of a ditch or culvert.

Permeable Soils

Soils through which water will drain easily e.g. sandy soils. Clays are generally impermeable except when cracked or fissured.

PART A - LIST OF TERMS

Riprap

Stones, usually between 5 to 50 kg, used to protect the banks or bed of a river or watercourse from scour.

Scour Checks

Small checks in a ditch or drain to reduce water velocity and reduce the possibility of erosion.

Soffit

The highest point in the internal cross-section of a culvert, or the underside of a bridge deck.

Underdrainage (Sub-Soil Drainage)

System of pervious pipes or free draining material, designed to collect and carry water in the ground.

Weephole

Opening provided in retaining walls or bridge abutments to permit drainage of water in the filter layer or soil layer behind the structure. They prevent water pressure building up behind the structure.

PART A- LIST OF TERMS

MAINTENANCE ACTIVITIES

Aggregate Brooming

Using a broom to spread chippings on a surface.

Attendant or Lengthman

A person contracted to maintain a section of road. Can be male or female and the term "Attendant" or "Lengthman" assumes either sex.

Compaction

Reduction in bulk of fill or other material by rolling or tamping.

Fog Seal

A very light film of binder sprayed onto a road to bind or enrich the surface.

Pass

A single longitudinal traverse made by a grader, roller or other piece of equipment working on the road.

Patching

The execution of minor local repairs to the pavement and shoulders.

Periodic Maintenance

Operations that are occasionally required on a section of road after a period of a number of years. They are normally large scale and require specialist equipment and skilled resources to implement, and usually necessitate the temporary deployment of those resources on the road section. These operations are costly and require specific identification and planning for implementation, and often require design.

Road Maintenance

Suitable routine, periodic and urgent activities to keep pavement, shoulders, slopes, drainage facilities and all other structures and property within the road margins as near as possible to their as-constructed or renewed condition. Maintenance includes minor repairs and improvements to eliminate the cause of defects and avoid excessive repetition of maintenance efforts.

Routine Maintenance

Operations required to be carried out once or more per year on a section of road. These operations are typically small scale or simple, but widely dispersed, and require skilled or un-skilled manpower. The need for some of these can be estimated and planned on a regular basis e.g. vegetation control.

Sanding

Spreading coarse sand onto a bituminous road surface that is bleeding.

Scarifying

The systematic disruption and loosening of the top of a road or layer surface by mechanical or other means.

Slurry Seal

A mixture usually containing fine graded aggregates, water, bitumen emulsion, cement and sometimes an additive, spread on the road surface by a specially equipped machine, or by hand.

Surface Dressing

A sprayed or hand applied film of bitumen followed by the application of a layer of stone chippings, which is then rolled.

Urgent Maintenance

Certain unforeseen situations necessitating remedial action to be taken as soon as possible, e.g. flood damage, slips.

Wind row

A ridge of material formed by the spillage from the end of the machine blade.

PART A - LIST OF TERMS

MAINTENANCE PLANT AND EQUIPMENT

4WD

Four Wheel Drive vehicle or equipment.

Aggregate Silo (Hopper)

Storage container for aggregate which is fed from the top and emptied from the bottom.

Bitumen Heater-Distributor Truck

A truck with an insulated tank and heating system, designed to apply a bituminous binder at an even and uniform rate of spread.

Drag

An apparatus towed behind a vehicle or piece of equipment to remove minor irregularities and redistribute loose surface material.

Gritter

A self propelled machine or an apparatus fitted to the back of a tipper truck, to spread chippings in a controlled and constant rate of spread.

PART A - LIST OF TERMS

Hoist

A hydraulic, mechanically or manually operated lifting device.

Hopper

The body of a road paving machine into which the premixed materials are tipped prior to spreading.

Mechanical Broom

Motor-operated rotary broom used to sweep loose material and objects from the pavement surface, usually attached to a tractor.

Mixing Plant

Mechanical plant designed to grade and mix mineral aggregates and binder to produce premix material.

Patching Vehicle

A specialist truck equipped with a bitumen tank of about 2000 litres capacity, with or without heater, cover for personnel, hopper for aggregate, and hand-spray lance.

PART A- LIST OF TERMS

Paver-Screed-Plate

A levelling device with a flat bottom mounted at the rear of the paver, which strikes off the fresh premix at the desired thickness and provides some initial compaction to the mix.

Ramps

Timber or steel planks for loading and unloading small items of equipment.

Road Paver

A self-propelled or tractor-drawn machine designed to evenly spread and partially compact aggregate mixtures.

Road Paver Adjusting-Blocks

Wooden blocks of the same thickness as the uncompacted premix mat, which are placed under the screed plate before spreading starts in order to adjust the thickness control. When starting from a previously laid mat, the block thickness equals the difference between the loose mat thickness and the rolled mat thickness.

Spray Lance

Apparatus permitting hand-application of bituminous binder at a desired rate of spread through a nozzle.

Squeegee

A small wooden or metal board with a handle for spreading bituminous mixtures by hand.

Torque Wrench

A spanner or wrench with a mechanism to indicate or yield when a pre-set torque is applied.

MATERIALS

Aggregate

Hard mineral elements of construction material mixtures, for example: sand, gravel, crushed rock.

Asphalt

Sometimes used to describe plant mixed bituminous materials. See also Bituminous Binder.

Asphaltic Concrete

A high quality manufactured mixture of bitumen and aggregates.

Bituminous Slurry (Slurry-Seal)

Mixture, usually of fine-grained aggregates, water, bituminous binder (emulsion), cement, and sometimes an additive, for a road surface seal.

Bituminous Binder, Asphalt

A petroleum oil based or natural product used to bind or coat aggregates for road pavements.

Chippings

Clean, strong, durable pieces of stone made by crushing or napping rock. The chippings are screened to obtain material in a small size range.

Cribwork

Timber or reinforced concrete beams laid in an interlocking grid, and filled with soil to form a retaining wall.

Gabion

Stone-filled wire or steel mesh cage. Gabions are often used as retaining walls or river bank scour protection structures.

Sand Mixtures

Sands of different gradings, mixed to provide the required material for a bituminous mixture.

Sod

As Turf but with more soil attached (usually more than 10 cms).

Tar Binder

A binder made from processing coal.

Turf

A grass turf is formed by excavating an area of live grass and lifting the grass complete with about 5 cms of topsoil and roots still attached.

PART A - LIST OF TERMS

SURVEY TERMS

Abney Level

Small hand held slope measuring and levelling equipment.

Camber Board

Apparatus for checking the crossfall of the road camber, or the shoulder.

Plumbing

Using a calibrated line, with a weight attached to the bottom, to measure the depth of water.

Profile

An adjustable board attached to a ranging rod for setting out.

Slot

A sample cross section of the road or drain constructed as a guide for following earthworks or reshaping.

PART A - LIST OF TERMS

Template

A thin board or timber pattern used to check the shape of an excavation.

Traveller

A rod or pole of fixed length (e.g. 1 metre) used for sighting between profile boards for setting out levels and grades.

Part B

WORKS MANAGEMENT AND SAFETY

GENERAL

The maintenance foreman or supervisor has an important role in the road maintenance operations. He is the road authority's or contractor's representative most in contact with the actual works.

He is usually responsible for the day to day scheduling of work, organising the resources, arranging safety measures, directing and controlling the work and preparing basic reports of the work carried out.

The **maintenance foreman or supervisor** must have and display qualities of:

- Responsibility
- Experience
- Consciousness
- Impartiality and honesty

in his dealings with labour, artisans and operators under his responsibility, and his supervisors.

This Part of the handbook provides some general guidelines on management for road **maintenance foremen and supervisors**.

SAFETY

Many Road maintenance operations are potentially dangerous, both to the maintenance workers and to the road users.

It is the responsibility of the **maintenance foreman or supervisor** to insist that all risks are minimised by:

- ensuring that the necessary temporary traffic signs and protection are provided and correctly located on site for the duration of the works. Where necessary, traffic should be stopped during the placement or removal of temporary signs,
- arranging for safety vests and helmets to be worn in appropriate circumstances, e.g. when working on the carriageways or shoulders, or on bridges,
- ensuring that all plant and vehicles are parked off the carriageway or behind protective barriers and signs, when not in use,
- ensuring that no materials are left in a dangerous location and that the road adjacent to the worksite is kept clean and swept of any debris arising from the maintenance work,
- ensuring that proper precautions are taken when handling dangerous substances e.g hot bitumen, corrosive or poisonous substances,

PART B - WORKS MANAGEMENT AND SAFETY

- ensuring that all excavations are protected for the benefit of all road users, equipment and workers,
- ensuring that all operators are trained in the operation of their equipment. If they are not adequately trained when they are assigned to the **foreman or supervisor**, he should himself provide, or arrange for, the necessary instruction. Operators and labourers alike must be informed of the potential risks of and procedures for working with or close to machinery,
- ensuring that traffic control operations are properly carried out and that road users are not unnecessarily delayed,
- ensuring all ladders or scaffolding used in bridge maintenance are securely fixed,
- ensuring that where work on the carriageway or shoulder remains unfinished overnight, then proper warning lights are arranged and, if necessary, protected,
- ensuring that all sites are left tidy and cleared of debris when the work is completed.

MANPOWER

This is **the vital** resource, whether operating machines or using handtools, for the success of the road maintenance operations.

A well motivated workforce will perform many times better than an unmotivated one.

The foreman or supervisor must play his part in motivating the workforce by:

- being firm and fair in all his dealings with the workforce,
- scheduling and organising the work so that it is efficiently carried out,
- arranging a fair workload for each member of the workforce,
- discussing and trying to resolve work and personnel problems as they arise,
- encouraging good quality work from the workforce and care of the equipment and handtools,
- ensuring that each member of the workforce is trained and able to carry out his allocated task. The **foreman or supervisor** should carry out or arrange any necessary initial or refresher training,
- ensuring that payment arrangements are timely, complete and correct.

ORGANISATION

The **maintenance foreman or supervisor** should schedule and organise work according to the **Worksheet** or other instructions.

Equipment and handtools should be arranged as necessary to carry out the task. Mechanical support arrangements will be necessary for sophisticated equipment or items working away from the base for extended periods. Fuel, lubricants, consumable spares, and daily servicing must be ensured to keep equipment operational.

Handtools should be of construction quality with proper handles; not merely tree branches cut and formed on site. Good quality handtools can significantly improve productivity and minimise injuries. Arrangements should be made to repair or replace worn or broken handtools.

Materials should be arranged and transported to site. They should comply with the specifications and be tested when necessary.

The signs and safety equipment should be arranged according to the guidelines or requirements.

The **foreman or supervisor** should ensure that equipment items are not misused.

Work may be carried out by a mobile gang, a gang located or recruited in the locality of the work and walking or cycling to work, or by individual attendants or lengthmen.

PART B - WORKS MANAGEMENT AND SAFETY

Daily tasks or targets should be used wherever possible. These work outputs should be developed from local experience. Ideally the workforce should be released for the day once their task has been achieved with regard to quantity and satisfactory quality.

Dayworks arrangements, whereby a worker stays for a set time period, usually achieves lower productivity. This arrangement should be avoided wherever possible.

Gangs, attendants or lengthmen may be set weekly or fortnightly tasks where supervision arrangements allow only infrequent visits for instruction and inspection.

The work should be recorded on the appropriate forms as accurately as possible. This helps to monitor the progress of the work and plan for future maintenance operations.

The **foreman or supervisor** is the "eyes and ears" of the Engineer, who necessarily can only make infrequent visits to the site. The foreman or supervisor should keep the engineer fully informed of progress on site and any problems encountered.

Finally it must be emphasised that the work of the **foreman or supervisor** is practically orientated. Most of his time should be spent on site organising and controlling work and solving the problems that occur there. Time spent in the office should be minimised, to carry out the necessary arrangements for support, administration, payments and reporting.

Part C

ROAD SIDE AREAS



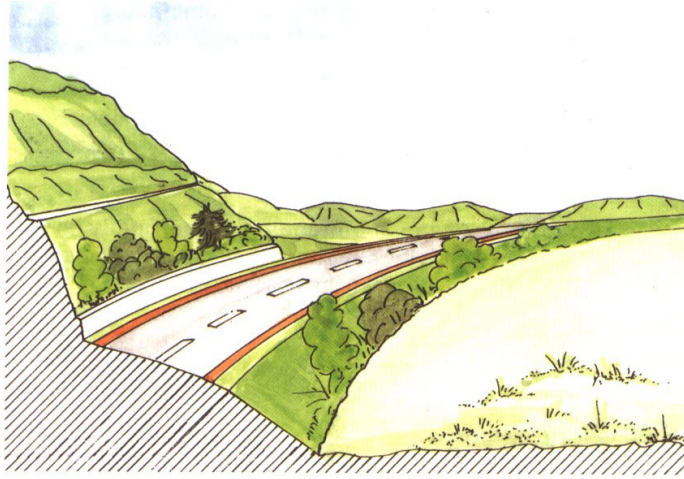
1. THE TASK

- **Roadside Areas** include the shoulders* and sideslopes, and all surface areas within the road margins* maintained by the Road Authority, except the carriageway*

Although these areas are normally not used by traffic, their maintenance contributes to the safety of road users and stability of the road.

- **Roadside Areas** maintenance is normally a ROUTINE* activity although occasionally some PERIODIC* maintenance activities are required.

See List of Terms, Volume I

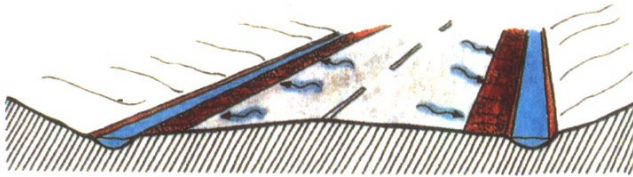
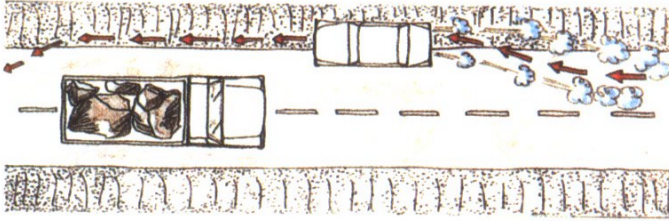
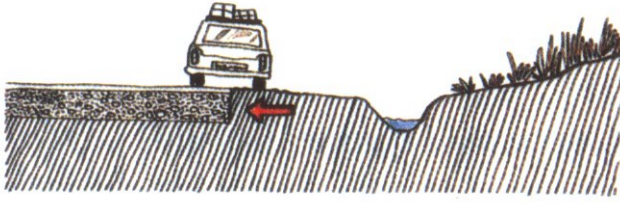


PART C - ROADSIDE AREAS

- Most **Roadside Areas** maintenance activities can be achieved by labour, and are suitable for being carried out by a mobile or local gang, or by an individual attendant or lengthman living close to the road.
- **Roadside Areas** consist of:
 - **shoulders** of paved roads,
 - **slopes** and other surface areas within the road margin.

Paved shoulders and laybys* are treated as paved* roads. Their maintenance is described in Volume III of the Handbook.

* See *List of Terms, Volume I*



PART C - ROADSIDE AREAS

1.1 SHOULDERS

- The OBJECT of shoulder* maintenance is to retain the shape and levels of the shoulder, so that:
 - the road pavement* has adequate side support,
 - traffic can safely use the shoulder in an emergency,
 - water drains from the carriageway* to the roadside ditch.
- **Shoulder** maintenance consists of the following activities

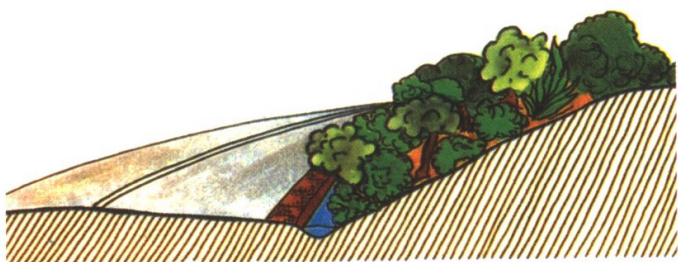
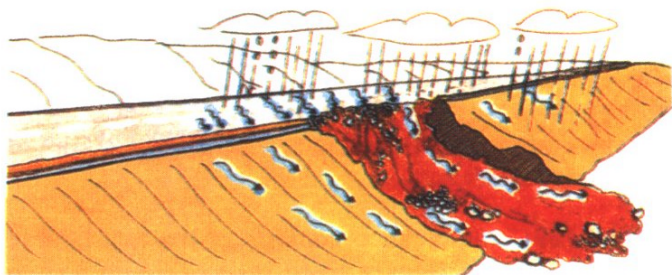
Routine* Activities

REMOVING OBSTRUCTIONS
RESHAPING SHOULDERS
VEGETATION CONTROL

Periodic* Activities

ADDING SHOULDER MATERIAL

* See *List of Terms, Volume I*.



PART C - ROADSIDE AREAS

1.2 SLOPES

- The OBJECT of maintenance of slopes and other roadside areas is to ensure that:
 - the slopes are protected against the potential erosion forces of water, and to retain their shape and stability,
 - the safety risk to road users is minimised due to poor visibility, grazing animals or fire hazard.

- Maintenance of **Slopes** and other roadside areas consists of the following activities:

Routine* Activities

VEGETATION CONTROL

Periodic* Activities

EROSION CONTROL
SLIP REPAIR

* See *List of Terms, Volume L*

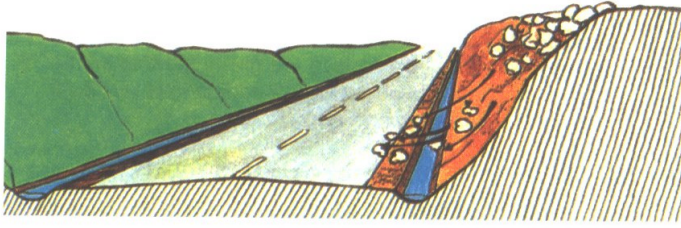


2. DEFECTS

2.1 LIST OF DEFECTS

On the following pages commonly occurring defects are shown. Their probable causes are given together with a suggested maintenance activity. In addition the results of neglected repair are mentioned:

- **Defect**
- **Main causes of the defect**
- **Development:** consequences if maintenance is not rapidly carried out,
- **Remedies:** usual repair treatments.



PART C - ROADSIDE AREAS

2.2 SHOULDERS

DEFECT: OBSTRUCTIONS ON SHOULDER*

Rocks, trees or tree branches, soil heaps, wind blown sand, abandoned vehicles/debris.

Main Causes

- material fallen from slopes or trees, material blown
- or washed onto the shoulders,
- debris left by road users.

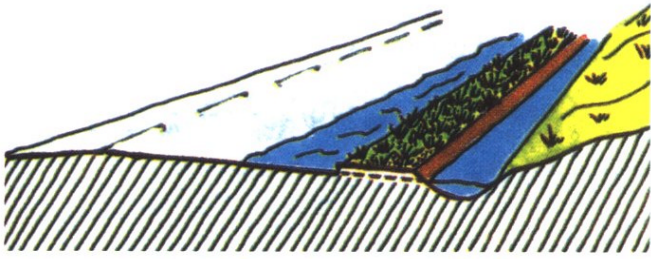
Development, if neglected

- hazard to road users,
- obstruction of water flow from carriageway*.

Remedies

- remove obstructions and dispose of safely.

* See List of Terms, *Volume I*.



SHOULDERS

DEFECT: SHOULDER HIGHER THAN CARRIAGEWAY, SHOULDER MISSHAPED

Main Causes

- carriageway* surface material has collected on the shoulder by the action of traffic/water,
- soil from the cutting has slipped onto the shoulder,
- vegetation has trapped material on the shoulder,
- shoulder material has been displaced by the action of traffic.

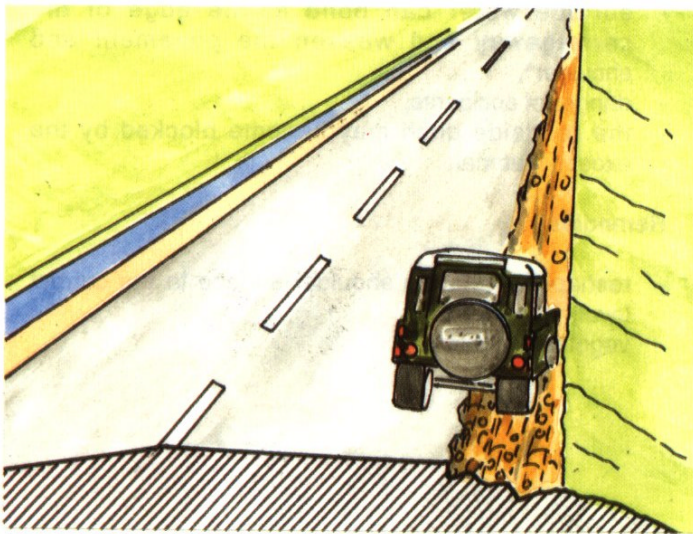
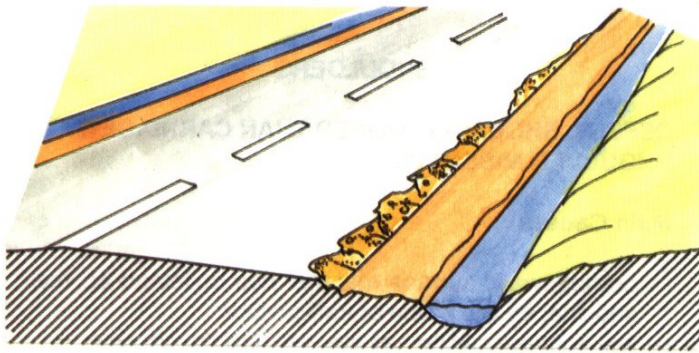
Development, if neglected

- surface water can pond at the edge of the carriageway and weaken the pavement and shoulder*,
- danger of accidents,
- the roadside ditch may become blocked by the excess material.

Remedies

- reshape or regrade shoulder surface to the correct level,
- vegetation control.

* See List of Terms, Volume I.



SHOULDERS

DEFECT: SHOULDER LOWER THAN CARRIAGEWAY, RUTS OR DEPRESSIONS

Main Causes

- traffic has been travelling on the sholder and material has been worn away,
- water erosion of the shoulder,
- settlement of the shoulder,
- the carriageway has been overlaid leaving the shoulder surface lower than the pavement*.

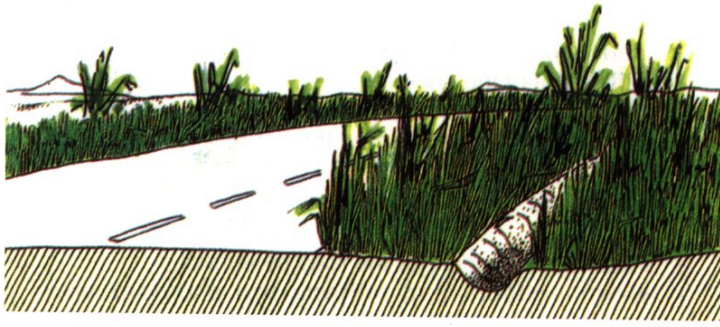
Development, if neglected

- inadequate support for the road pavement,
- water collects and softens the shoulder and pavement* foundation,
- the edge of the pavement will break when vehicle wheels run over it,
- increased risk of accidents.

Remedies

- add shoulder material.

* See *List of Terms, Volume I*.



SHOULDERS

DEFECTS: HIGH VEGETATION ON SHOULDER

Main Causes

Grass, weeds, bushes or trees have been allowed to grow unchecked.

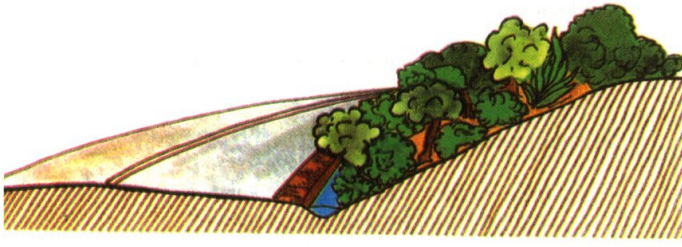
Development, if neglected

- surface water can pond at the edge of the carriageway and weaken the pavement*,
- silt accumulates at the edge of the carriageway,
- the visibility for road users is reduced, with increased risk of accidents with persons or animals,
- increased fire hazard in the dry season.

Remedies

- vegetation control.

* See List of Terms, Volume I.



2.3 SLOPES

DEFECT: VEGETATION OVERGROWN ON SLOPES

Main Causes

- insufficient grass cutting, bush clearing and tree trimming.

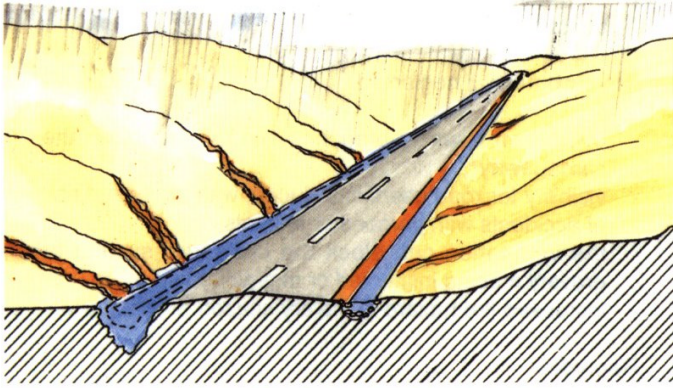
Development, if neglected

- overgrown trees or branches can fall and block the carriageway*,
- visibility for road users is reduced, with increased risk of accidents with persons or animals,
- the vegetation can block the drainage system or prevent it being inspected or maintained,
- increased fire hazard in the dry season.

Remedies

- vegetation control.

* See List of Terms, Volume I.



SLOPES

DEFECT: SURFACE WATER EROSION

Main Causes

- rainwater concentrated into channels at the top of the slope,
- lack of vegetation cover.

Development, if neglected

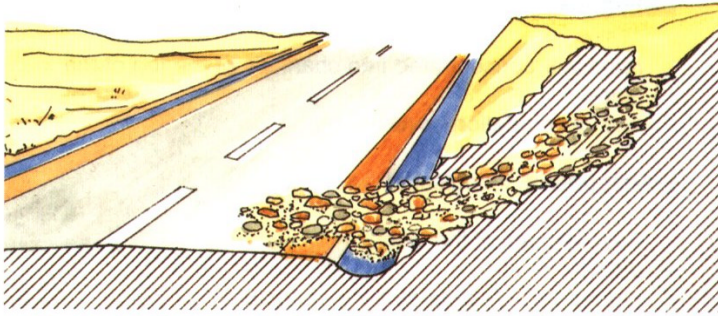
- deep erosion of the slope,
- slips*,
- obstruction of roadside ditch or shoulder*.

Remedies

Erosion prevention or repair by means of:

- berm*,
- cut-off ditch for cuttings,
- kerb or channel drain and chute* for embankments,
- turfing,
- seeding,
- waffling,
- stone pitching.

* See List of Terms, Volume L



SLOPES

DEFECT: EARTH SLIP

Main Causes

- the slope was too steep for its height, and the soil,
- water penetrating the slope from above,
- ground water pressure or flow.

Development, if neglected

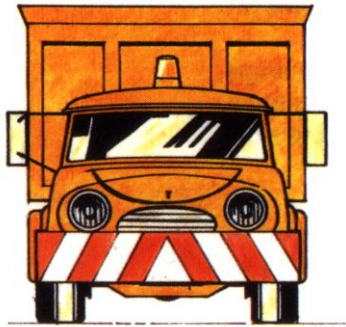
- the soil in the slope may continue to move downwards, blocking/cutting the roadway,
- water in roadside ditches cannot flow and ponding will occur.

Remedies

Slip repair by means of:

- reducing slope angle,
- clearing slip material,
- surcharging the slope,
- gabjons*,
- cribwork,
- masonry retaining wall,
- concrete retaining wall.

* See *List of Terms, Volume L*



3. RESOURCES

The following recommendations relate to carrying out the work using a mobile gang.

Where appropriate, options for equipment or labour methods are described.

Reduced transport resources will be required if the work is carried out by a local gang, with labourers walking to and from work each day.

The gang size and other resources will be varied depending on the type and number of activities, the quantity of work to be achieved, and the resources available.

Many of the activities described can be carried out by an attendant or lengthman. This approach is described in Pages I –149 to I -161.



PART C - ROADSIDE AREAS

3.1 PERSONNEL

From the following resources.

■ Supervisors

- 1 foreman or overseer visiting regularly,
- 1 headman for each 10 to 20 workmen.

■ Plant Operators and Drivers

- 1 light vehicle driver (for foreman or overseer)¹,
- 1 tipper/flat bed truck driver²,
- 1 tractor-mower driver³,
- 1 tractor-trailer driver⁴,
- 1 tractor driver and 1 towed grader operator, or 1 motorgrader operator⁵,
- 1 water tanker driver⁵,
- 1 roller operator⁵,
- 1 bulldozer operator⁶,
- 1 loader operator⁶,
- 2 additional tipper drivers⁶,

1 If a light vehicle is used,

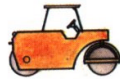
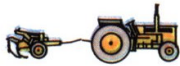
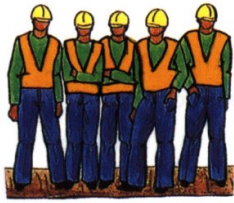
2 If a mobile gang is used, or for materials/debris transport,

3 If vegetation control is mechanised,

4 Alternative for transporting materials and shoulder gravel up to about 10 km,

5 If shoulder repairs are carried out by mechanised methods,

6 If slip repair and slope stabilisation are carried out by mechanised methods.



PART C -ROADSIDE AREAS

■ Workforce

- 1 to 2 masons,
- 10 to 20 workmen,
- 2 traffic controllers (when working on the shoulders).

3.2 PLANT AND TOOLS

From the following resources.

- 1 light vehicle or motorcycle,
- 1 tipper/flatbed truck or tractor-trailer (part-time)¹,
- 1 tractor with mower or rotary brush cutter attachment² 1 tractor and towed grader, or 1 motorgrader³,
- 1 roller³,
- 1 water tanker³ with water pump,
- 1 bull doze¹,
- 1 wheeled or racked loader⁴,
- 2 additional tipper trucks⁴,

1 For transporting mobile gang or transporting debris or materials,

2 If vegetation control is mechanised,

3 If shoulder repairs are carried out by mechanised methods,

4 If sip repair and slope stabilisation are carded out by mechanised methods.

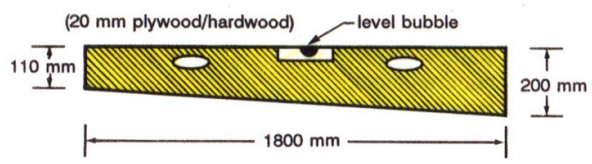


PART C - ROADSIDE AREAS

■ Small items of Equipment¹

- 1 slasher, sickle or scythe per workman,
- 1 rake or hayfork per workman,
- 1 bushknife per workman,
- 5 hoes for every 10 workmen,
- 5 shovels for every 10 workmen,
- 5 mattocks for every 10 workmen,
- 2 sledgehammers,
- 4 handrammers,
- 2 brooms,
- 2 pickaxes,
- 2 crowbars,
- 2 bow saws,
- 1 two-man saw,
- 2 brush hooks,
- 2 axes,
- 2 to 8 wheelbarrows,
- 2 files (for sharpening tools),
- 1 small vibrating roller or plate compactor,
- ropes for tree felling,
- 1 ladder for tree felling,
- handtools for retaining wall construction.

1 Depending on activities to be carried out.



PART C-ROADSIDE AREAS

■ Tool and supplies

To check the finished shoulder crossfall* a camber board will be required, made from 20 mm treated plywood or hardwood to give a 1 in 20 (5%) slope.

- lubricating oils for equipment**,
- setting out aids for retaining walls**.

■ Support**

If mechanised methods are used for slip repair and slope stabilisation. A low loader will be required to transport some of the equipment items to and from the work site.

* *See List of Terms, Volume L*

** *If applicable.*



3.3 MATERIALS¹

- **Gravel** obtained from a quarry or gravel pit for shoulder repairs must be of a quality that meets the Departmental Specifications and also be approved by the **Maintenance Engineer**.
- A source of **water** will be needed as near as possible to the site for shoulder repairs.
- Materials for **retaining wall** construction to according to Departmental designs and specifications:
 - aggregates, sand, cement,
 - masonry stone or brick, or blocks,
 - gabion wire baskets,
 - 3 mm binding wire,
 - wooden stakes,
 - gabion filling stone,
 - cribwork* components(timber or concrete),
 - sandbags

¹ Depending on activities to be carried out.

* See List of Terms Volume L.



2



2



2



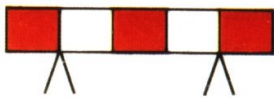
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3.4 SIGNS AND SAFETY EQUIPMENT

When adding gravel to the shoulders or for slip repairs, the following items should be provided where possible¹.

■ **Traffic Signs**

- 2 Reversible **"Stop/Go"** signs,
- 2 **"Speed Limit"** signs (50 km/hr)*,
- 2 **"Men Working"** signs*
- 2 **"No Overtaking"** signs,
- 1 **"Road Narrows From Right"** sign,
- 1 **"Road Narrows From Left"** sign,
- 2 **"End of Restriction"** signs*.

■ **Barriers**

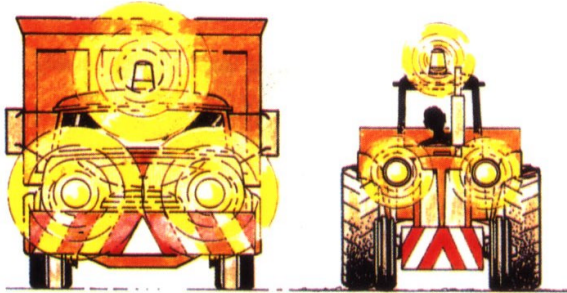
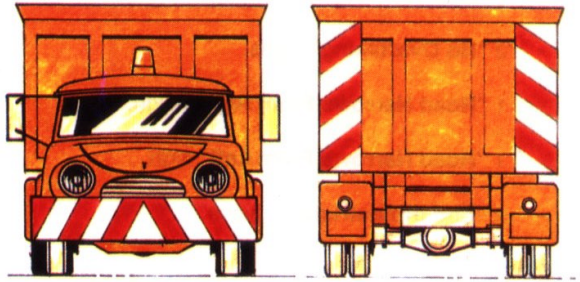
- 2 lane closure barriers.

■ **Traffic Cones**

As many as are required; at least 10 will usually be needed.

1 For other Roadside Areas maintenance tasks, only the asterisked items may be required. When carrying out dispersed tasks, the following additional signs may be required.*

- 2 **"Grading Shoulders"** signs,
- 2 **"Mowing"** signs.



PART C - ROADSIDE AREAS

• Safety Equipment

Use should be made of the following equipment for personnel and the different vehicles as far as possible:

- yellow/orange shoulder belts for the foreman, and the other workmen working on the shoulders,
- red and white striped marker boards attached to all vehicles and plant.

TYPICAL WORKSHEET

ROADSIDE AREAS

Worksheet No: Date:

District

Zone: Gang:

Road No.: from to

Location(s):

Work to be carried out:

Work to be completed by: (Date)

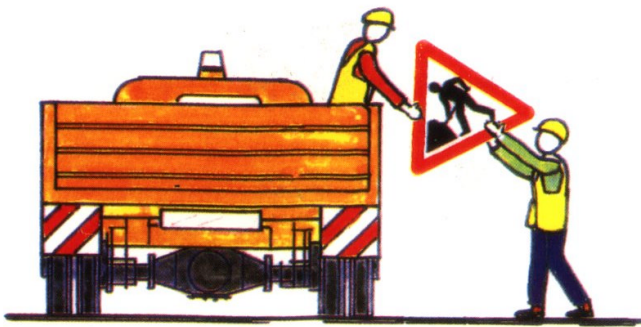
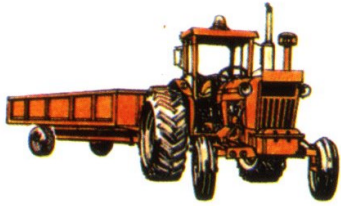
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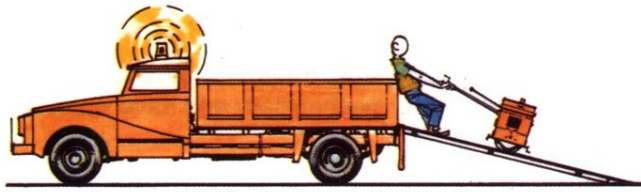
METHOD A: MOBILE GANG

4. MAINTENANCE METHOD

4.1 PRELIMINARY TASKS

- **The Worksheet** will indicate the location and extent of the work to be carried out and the time, equipment and personnel required for the job.





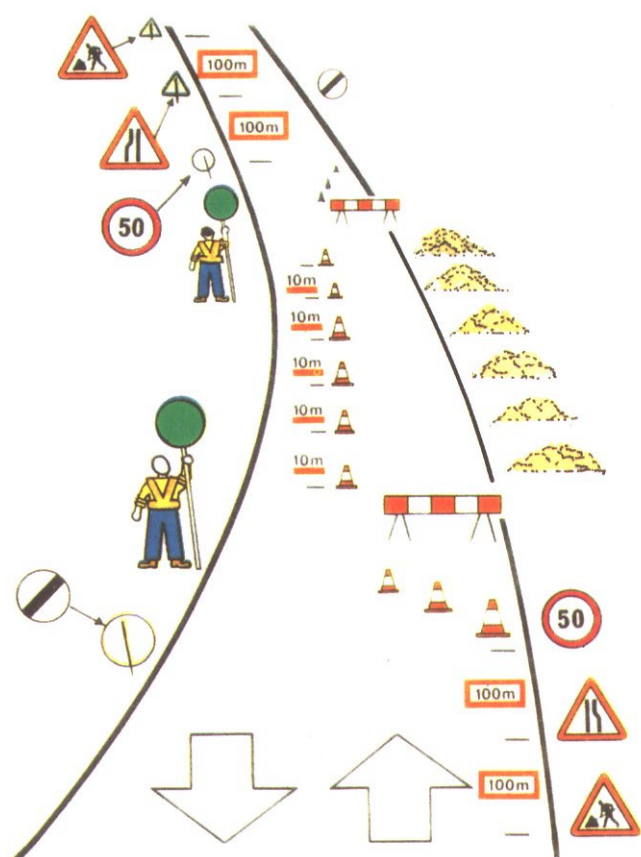
PART C - ROADSIDE AREAS

- **Tools and small equipment** must be obtained and loaded onto the truck or trailer. The roller may be loaded with the help of ramps* or a hoist*.

- Arrangements must be made for obtaining water for shoulder repairs.

- Arrangements must be made to load **gravel** onto the truck or trailer either at the depot or at a quarry.

* See *List of Terms, Volume L*



METHOD A: MOBILE GANG

4.2 TEMPORARY SIGNPOSTING

When adding gravel to the shoulders, or for slip repairs, warning signs, barriers and cones must be placed around the work area.

Work should be carried out on one side of the road at a time, allowing traffic to pass on the other.

Signs must be placed in the following order:

- **"Men Working"** signs should be placed **200 metres** in front of the work area.
- **"Road Narrows"** signs should be placed **100 metres** in front of the work area.
- **"Speed Limit"** signs should be placed at the start of the work area.
- **Barriers** should be placed at each end of the work area.
- **Cones** should be placed in a taper at the approaches to the work area and at a maximum spacing of 10 metres along the middle of the road next to the work area.
- **"End of Restriction"** signs should be placed **50 metres** beyond the work area.



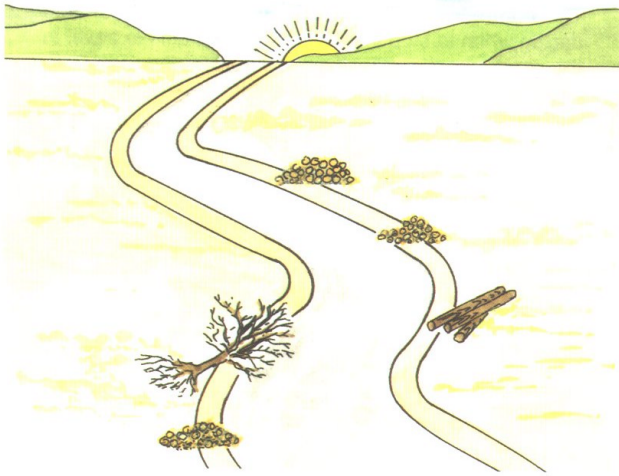
PART C - ROADSIDE AREAS

- **Traffic controllers** should stand next to the barriers in the centre of the road to operate the reversible **"Stop/Go"** signs.

The controller closest to the oncoming traffic should decide when to stop the flow and allow traffic to travel in the other direction. Traffic should be stopped in both directions when works vehicles enter, leave or turn at the worksite.

On low-traffic roads or for other Roadside Area's tasks, the Maintenance Engineer may approve the use of a simpler system of traffic control:

- Only the **"Men Working"** and **"End of Restriction"** signs may be required for most Roadside Areas tasks,
- when reshaping the shoulders by motor or towed grader, **"Grading Shoulders"** signs should be placed alongside the **"Men Working"** signs,
- when grass cutting with a tractor, **"Mowing"** signs should be placed alongside the **"Men Working"** signs.



METHOD A: MOBILE GANG

4.3 EXECUTION OF THE WORK

Shoulders

REMOVING OBSTRUCTIONS

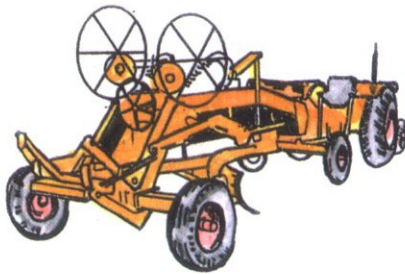
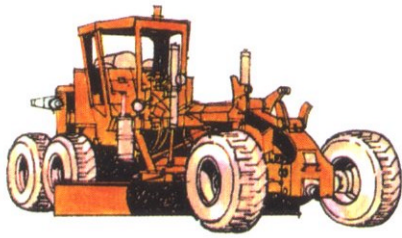
This is a **Routine*** activity.

Obstructions such as rocks, fallen trees or branches, soil heaps, windblown sand, abandoned vehicles/debris, are a hazard to road users and may prevent the flow of water from the carriageway to the drainage system.

These obstructions should be loaded onto a truck or trailer, or otherwise removed from the shoulder, and disposed of at a safe location. Materials can often be spread safely on adjacent slopes.

This activity is often carried out in conjunction with other tasks.

* See *List of Terms, Volume L*



Shoulders

RESHAPING SHOULDERS

This is a Routine* activity, to repair high or mis-shaped shoulders.

a) Mechanised Method

The existing surface of the shoulder should be scarified* with the tines of a motor or towed grader. This will loosen the raised areas and allow the loosened material to key into any existing low areas.

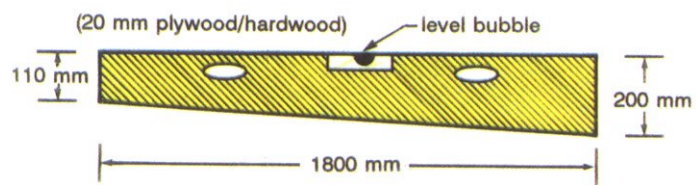
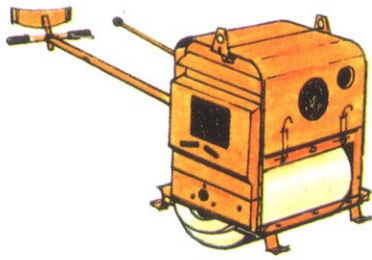
The shoulders should be reshaped to slightly above the final level and the correct crossfall using the motor or towed grader blade.

Care must be taken not to damage the edge of the road pavement* with the blade.

The cross fall of the uncompacted material should be checked with a camber board.

Excess material and vegetation should be graded to the embankment side slope. In cuttings, excess material and vegetation should be graded into a windrow* for removal by wheelbarrow, tractor and trailer or truck. Material should not be deposited on the carriageway* or into the drainage ditch.

* See List of Terms, Volume I.



PART C- ROADSIDE AREAS

If the material is dry it should be sprinkled with water.

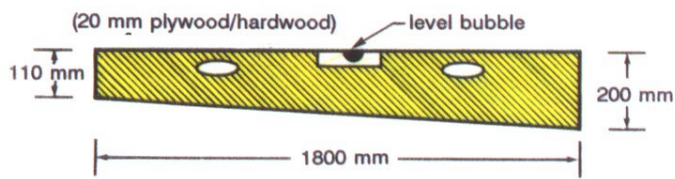
The shoulder is then compacted using a self propelled, towed or pedestrian roller.

The compacted surface should butt smoothly onto the road pavement*.

Check the finished crossfall* with the camber board and repeat the reshaping if necessary.

Brush all loose material and debris from the carrageway*.

**See List of Terms, Volume 1*



PART C - ROADSIDE AREAS

b) LabourMethod

The low surfaces and all high material should be loosened with a pick axe or mattock.

The shoulder should be reshaped to slightly above the final level and the correct crossfall using a shovel and rake.

The crossfall of the uncompacted material should be checked with a camber board.

Excess material should be spread over the embankment slope or transported by wheelbarrow to a convenient and safe dumping site. Material should not be deposited on the carriageway* or in the drainage ditch.

If the material is dry it should be sprinkled with water.

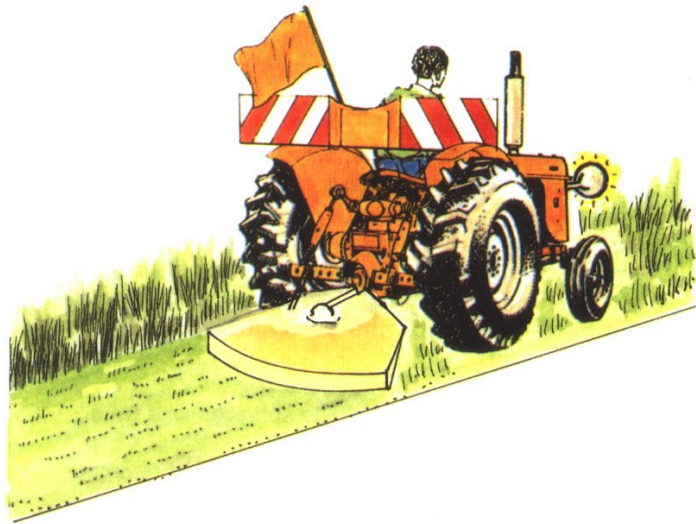
The shoulder is then compacted with hand rammers or a hand roller.

The compacted surface should butt smoothly onto the road pavement*.

Check the finished crossfall* with the camber board and repeat the reshaping if necessary.

Brush all loose material and debris from the carriageway*.

* See List of Terms, *Volume I*.



PART C-ROADSIDE AREAS

Shoulders

VEGETATION CONTROL

This is a **Routine*** activity, involving control of grass, weeds, bush and trees.

With the exception of arid areas, grass and weed cutting and bush clearing on shoulders* is a basic maintenance activity. It is carried out at least once a year after the rainy season, or more often where the climate causes vegetation to grow rapidly.

Most of the activities required for this task may be carried out by an agricultural tractor equipped with a sicklebar mower, flail mower or rotary brush cutters.

Alternatively all of the activities may be achieved using labour and handtools.

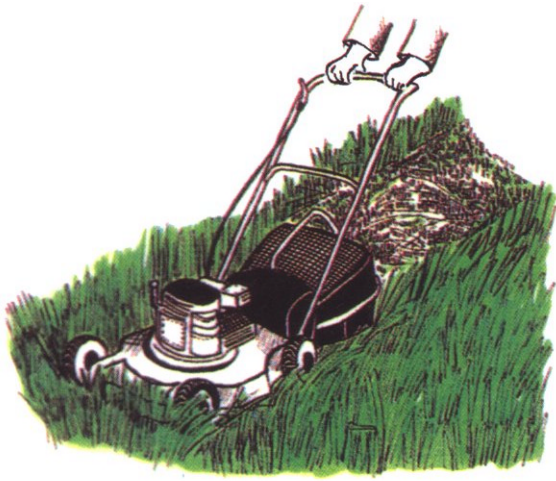
■ Grass Cutting and Bush Control.

Grass, weeds and bush should be cut at least once a year after vegetation reaches full growth or according to local experience.

a) Mechanised Method

- mow only on level ground, free from obstructions and debris,
- do not mow when grass is wet, if experience shows this to be unsatisfactory,
- mow all shoulder areas between pavement and edge of road side ditch.

* See *List of Terms, Volume L*



PART C-ROADSIDE AREAS

As an alternative to the tractor-drawn sickle-bar mower, a hand-guided sickle-bar power mower or power flail mower can be used. The hand-guided mower will have a lower output than the tractor-drawn equipment, but it has the advantage of being able to operate on slopes* of about 1 to 1.5.

Where only small areas need to be mowed, a small rotary grass mower may be appropriate.

- part of the workforce should work well ahead of the mower, removing obstructions, debris and bush stems in the path of the mower which could damage sickle-bar cutters.

Ditches should be cleared of all unnecessary vegetation including the areas around fixed traffic control devices, which cannot be cut by mower,

- the supervisor should mark out any areas on the inside of curves which extend behind the shoulder* and ditch, and where bush cutting is required to improve the line of sight for road users,
- bush and grass cuttings left behind machines should be removed from the shoulder. Rake these into stacks at short intervals and remove them well away from the roadside so that they cannot block the drainage ditches. Debris should not be burned causing a hazard to traffic or surrounding vegetation,

* See *List of Terms, Volume L*



The use of all mowing and cutting equipment is potentially hazardous. Particular care must be taken when using this equipment and clearing any blockages.

b) Labour Method

As an alternative to mowing and in areas inaccessible to power equipment, (especially ditch side-slopes or on other steep slopes), the vegetation should be trimmed by hand. Sickles, scythes, slashers, bushknives, axes, saws or similar handtools will be required.

■ Trees

Dead or leaning trees within the right-of-way which may fall on the carriageway* or block the drainage* system, or block sight lines should be removed. The felling of trees, or the removal of large branches at heights of more than 2 metres above ground level can be hazardous. This work should only be carried out under expert supervision or by experienced workers.

Trees should be felled using two-man saws or axes. Ladders should be used for climbing trees, and ropes should be used to restrain trees and control felling. Traffic should be halted when the tree is finally toppled. All debris should be removed and disposed of safely.

* See List at Terms, Volume I.



PART C - ROADSIDE AREAS

■ Herbicides

Herbicides (weed-killer) are chemical agents intended to destroy or reduce vegetation growth. It is not recommended that herbicides or any chemical methods be used to control roadside vegetation. Some reasons are:

- herbicides can cause pollution of crops, rivers and streams and drinking water supplies,
- herbicides are often dangerous to health,
- herbicides are expensive, and must often be imported,
- herbicides do not always produce satisfactory results.

■ Burning

Do not burn roadside vegetation to control its growth or the debris from Vegetation Control activities. The results may be more harmful than desired:

- the fire could spread and destroy valuable vegetation (trees, grass), and traffic control devices,
- vegetation may grow faster after burning,
- smoke and flames blowing across the highway are dangerous for traffic.



PART C-ROADSIDE AREAS

Shoulders

ADDING SHOULDER MATERIAL

This is normally a **Periodic*** activity to repair shoulders that have settled, or been eroded by traffic and water. It is also required when an overlay is applied to the road pavement*.

a) Mechanised Method

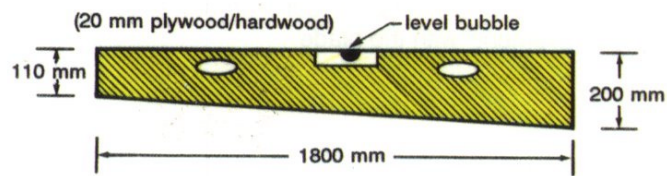
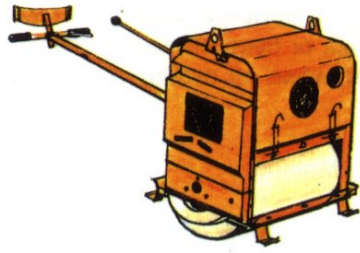
The existing surface of the shoulder should be scarified* with the tines of a motor or towed grader. This will loosen the surface and allow a key for the added material.

New shoulder material is oft-loaded or tipped onto the shoulder, allowing a small surplus to requirements.

The added material should be shaped to slightly above the final level and the correct crossfall using the motor or towed grader blade.

Care must be taken not to damage the edge of the road pavement* with the blade.

See List of Terms, Volume 1



PART C - ROADSIDE AREAS

The crossfall of the uncompacted material should be checked with a camber board.

Excess material should be graded to the embankment side slope. In cuttings, excess material should be graded into a windrow* for removal by wheelbarrow, tractor and trailer, or truck. Material should not be deposited on the carriageway or into the drainage ditch.

If the material is dry it should be sprinkled with water.

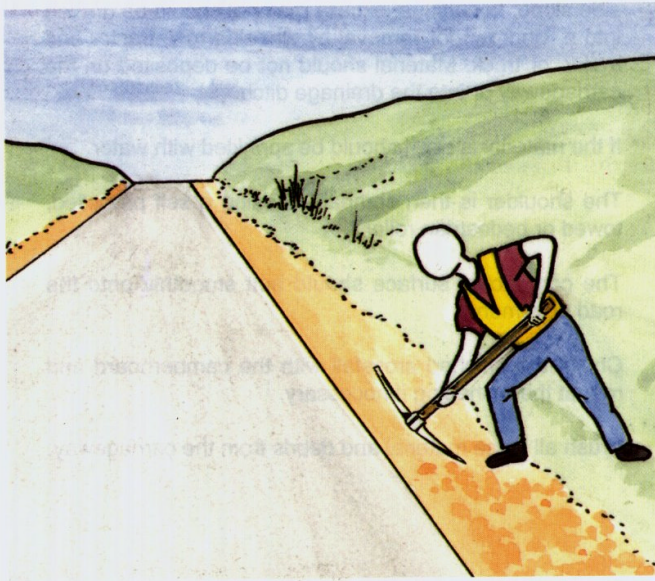
The shoulder is then compacted using a self propelled, towed or pedestrian roller.

The compacted surface should butt smoothly onto the road pavement*.

Check the finished crossfall with the camberboard and repeat the reshaping if necessary.

Brush all loose material and debris from the carriageway.

* See *List of Terms, Volume J*.



PART C-ROADSIDE AREAS

b) Labour Method

The existing surface of the shoulder should be loosened with a pickaxe or mattock to allow a key for the added material.

New shoulder material is off-loaded or tipped onto the shoulder, allowing a small surplus to requirements.

The added material should be shaped to slightly above the final level and the correct crossfall using a shovel/hoe and rake.

The crossfall of the uncompacted material should be checked with a camber board.

Excess material should be collected and transported by wheelbarrow for use further along the shoulder or discarded safely by spreading over the embankment slope or at a convenient location.

If the material is dry it should be sprinkled with water, using containers or a small water bowser.

The shoulder should be compacted using a hand rammer or a hand roller.

Check the work and clear debris as for the Mechanised Method.



Slopes

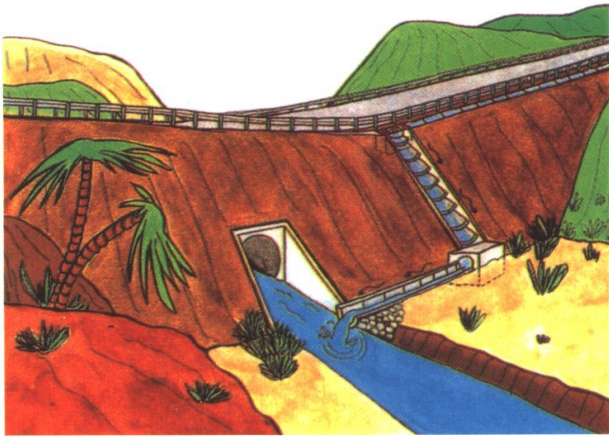
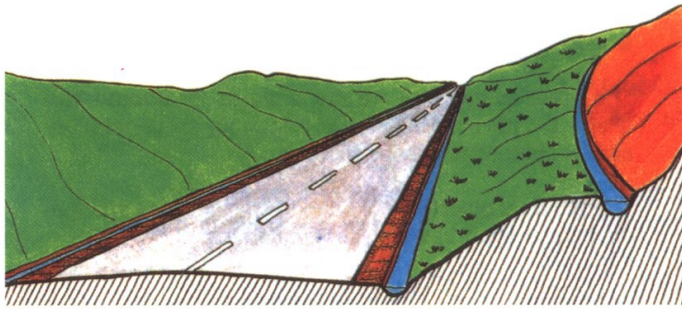
VEGETATION CONTROL

This is a **Routine*** activity involving the control of grass, weeds, bush and trees.

The activities involved are the same as for **shoulders*** (Page I - 101), however the frequency of vegetation control operations may be reduced.

The principal objective will be to keep sight lines and the drainage system free of excess vegetation.

** See List of Terms, Volume I.*



Slopes

EROSION CONTROL

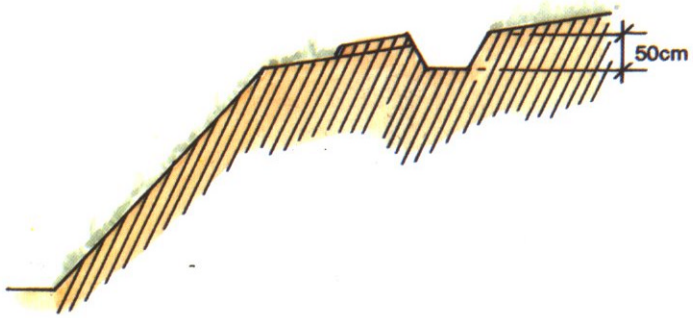
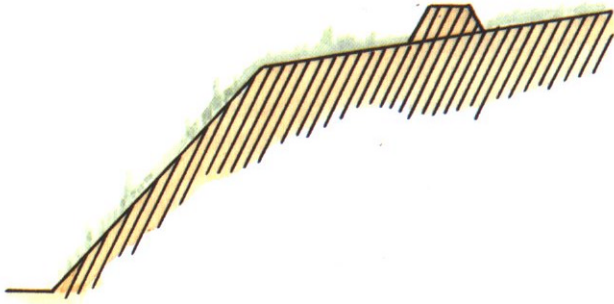
This is a **periodic*** activity, although its requirement is usually very localised.

Erosion is usually caused by rainwater concentration on the slopes or by lack of vegetation cover.

A number of options can be used to prevent or repair erosion on slopes and other Roadside Areas:

- berm for cuttings,
- cutoff ditch for cuttings,
- kerb or channel drain for embankments,
- turfing,
- seeding,
- wattling,
- stone pitching.

* See *List of Terms, Volume L*



PART C-ROADSIDE AREAS

■ Berms for cuttings

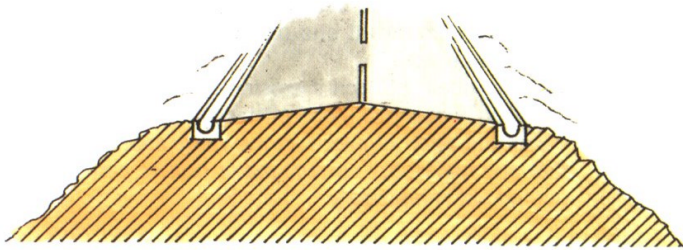
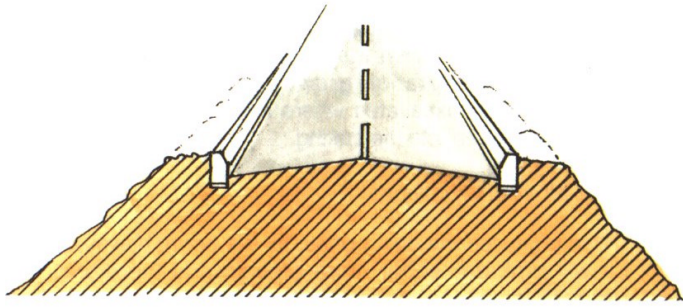
A soil berm or bund can be built by hand along the top of a cutting face to prevent surface water flowing over the cutting face. The berm should be located to lead all water to a safe location for discharge or dispersal. The berm may need to be seeded to encourage vegetation growth and stability. Soil should not be excavated where it will allow water to pond or to seep into the cutting.

■ Cut-off ditch for cuttings

This produces the same effect as the berm, however it will probably suffer more erosion and therefore require more maintenance. A cut-off ditch is not suitable for permeable* soils.

- determine location and alignment of ditch from local inspection; not too close to the edge of the slope. Follow the natural contour of the hill as closely as possible but with enough grade to permit water to flow,
- excavate ditch to about 50 cm depth. The sides of the ditch must not be too steep, otherwise they will collapse into the ditch and cause a blockage. Excavated material should be spread on the **downslope** side,
- protect outfall* of ditch if erosion is likely, by use of turfing, wattling or stone pitching,
- check the ditch regularly in the rainy season so that any necessary corrections or repairs can be carried out immediately.

* See List of Terms, Volume L



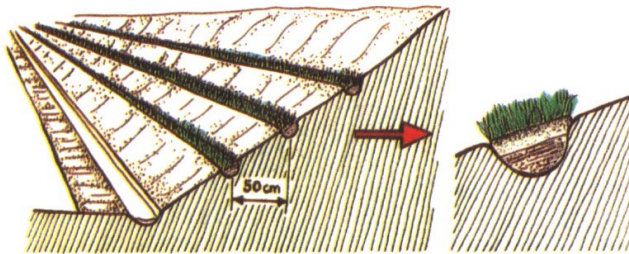
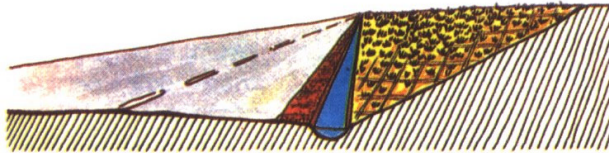
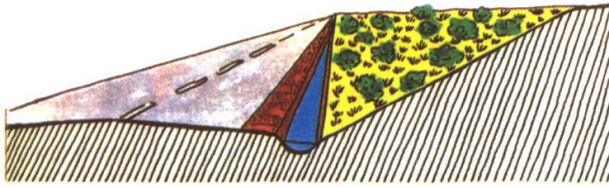
PART C - ROADSIDE AREAS

■ kerb or Channel drain, for embankments

A kerb or channel drain may be built at the edge of the carriageway or the back of the shoulder. The kerb may be of dressed stone, precast or insitu concrete. If the gradient falls throughout the embankment the kerb or drain may discharge at the cut-fill location. If there is a low point on the embankment, a chute* or cascade* will be required to safely discharge the water down the slope.

For further details See Page I - 247.

* See *List of Terms, Volume I*



■ Turfing (grass sodding)

This method is suitable when climate and soil conditions are favourable and when fresh grass sods* (soil clumps containing grass and its roots) are available.

The general procedure is:

- prepare the area to be turfing* to required levels and slopes,
- where no topsoil is present, haul suitable topsoil to site and spread evenly to a depth of not less than 5 cm. Water as required,
- cover the area with freshly cut sods without weeds. Sods are to have thickly matted roots which should not have dried out. Tamp sods with tamper or use hand roller. On slope use stakes to hold sods in position,
- water the turves at intervals until the grass takes hold.

Other patterns of sodding are:

- spot sodding (sods spaced about 50 cm in holes deep enough to take sod and about 5 cm topsoil),
- trench sodding. Lay sods on 5 cm topsoil bed in parallel trenches. Trench spacing about 50 cm along contour or x-shaped pattern.

* See *List of Terms, Volume 1*.



PART C - ROADSIDE AREAS

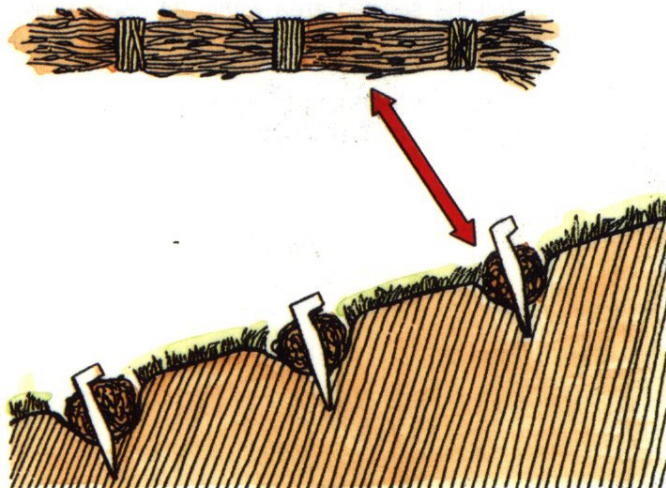
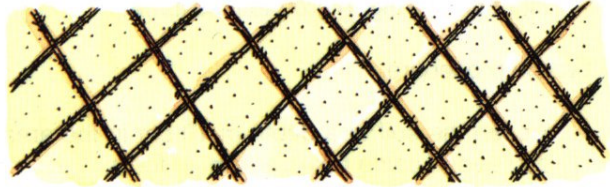
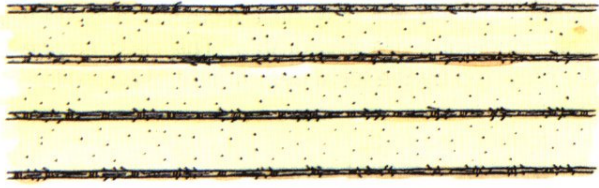
■ Seeding

Grass seeding will only be successful if climate and soil conditions are favourable. The best advice can be provided by the local department of agriculture on:

- topsoil required,
- seed type, rate of spread,
- fertilizer types, rate of spread,
- most favourable season and weather for seeding,
- other preparatory treatment of the soil (for example mixing-in ground limestone).

Typical procedure:

- loosen the soil to a depth of 10 cm in the area to be seeded using rakes or similar tools,
- spread the topsoil to a depth of at least 5 cm,
- water the area to be seeded,
- apply fertilizer at the specified rate,
- apply ground limestone at the specified rate and mix-in,
- apply seeds by hand at the specified rate,
- lightly roll the seeded area within 24 hours using hand roller, only if the soil does not adhere to the roller,
- the seeded area should be watered as required until the grass has taken hold.



PART C-ROADSIDE AREAS

■ Wattling

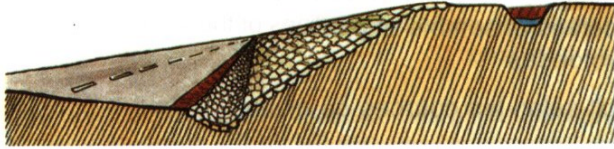
These are bundles of plant stems up to 3 m long, tied together and laid in shallow trenches, staked into position on contour lines (lines of the same height), or x - form lines.

As with turfing and seeding, a favourable climate and soil conditions are essential for the successful use of wattling.

Wattling helps to stabilize slopes, reduce surface erosion and provides a bench on which grass can become established. Plant stems which root easily are preferred. Advice on suitable plants and planting time should be obtained from the local department of agriculture.

Typical procedure:

- cut wattling stems at suitable source and transport them to site immediately. Stems should not be allowed to dry
- cut, tie bundles of stems 15 - 20 cm diameter, alternating the ends,
- excavate a trench in the slope along the desired line. The trench should be deep enough to accommodate tied wattling stems (this work can be completed beforehand),
- place wattling stems in trench and use stakes to fix them in position. Overlap bundles and stake through the overlaps,
- cover the wattling with topsoil and tamp them firmly in place, -watering may be necessary until the roots take hold.



PART C - ROADSIDE AREAS

■ Stone Pitching

This work is generally limited to small but important areas, for example* or culverts.

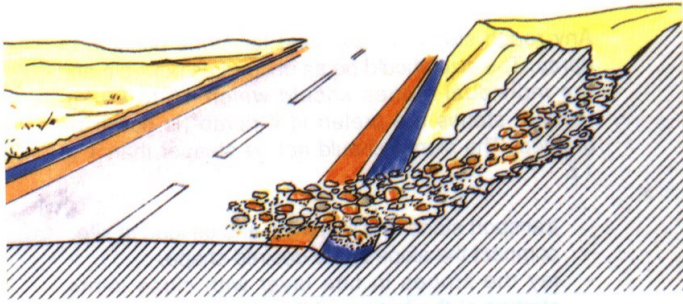
Any rough stone can be used for stone pitching or riprap. The size should be as uniform as possible and the individual stones should weigh 10 to 20 kg. Heavier stones are preferred if riprap* is not to be grouted. The slope* should not be steeper than 1 to 1.5.

- transport stone and materials and off load at site,
- compact the slope to the desired shape,
- lay the stones in one layer with close joints, starting at the bottom of the slope with the larger stones. Stones should be supported by soil, smaller stones may be used to help wedge them in place. Larger stones should be buried deeper so that the final top surface will be uniform.

When the stone pitching is to be grouted:

- wet the stone as thoroughly as possible,
- grout the spaces between stones with a mortar (1 cement: 4 sand),
- brush surface of the stone pitching with a stiff broom,
- protect the work from the sun using sacks or similar material, and keep wet for at least 3 days after grouting.

* See List of Terms, Volume L



Slopes

SLIP REPAIR AND SLOPE STABILISATION

This is a **periodic*** or Urgent activity, although its requirement is usually very localised.

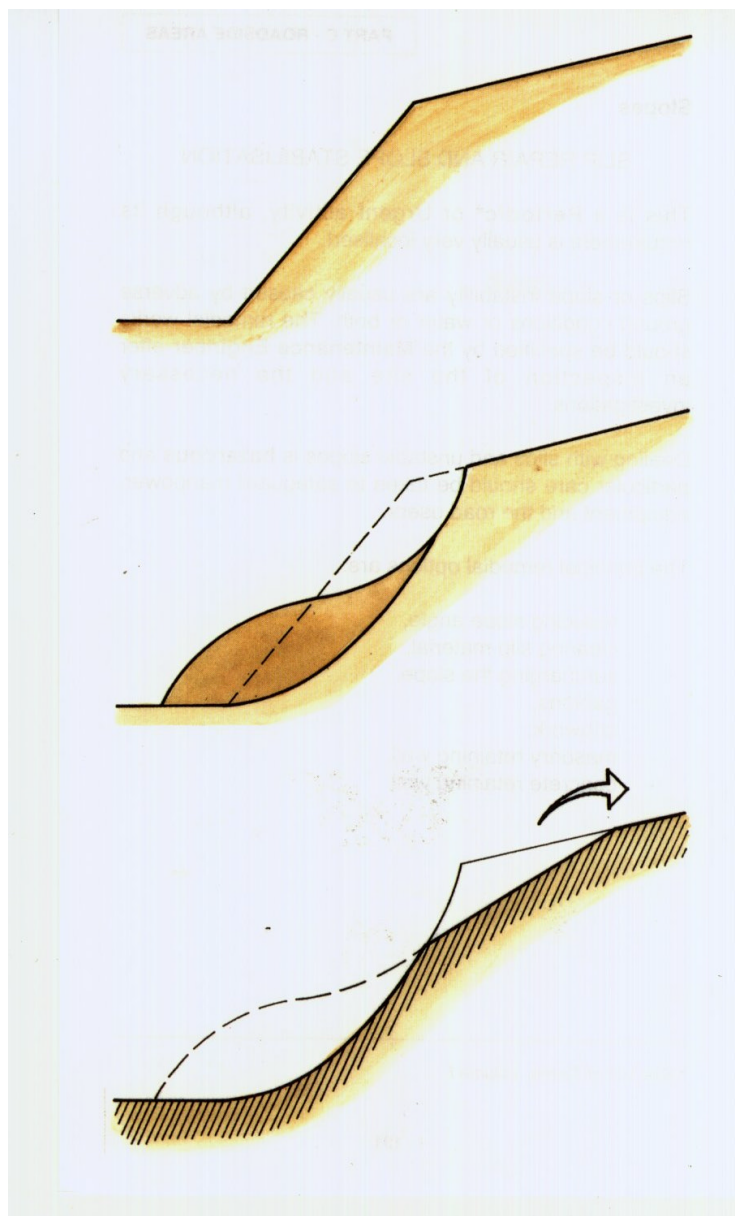
Slips or slope instability are usually caused by adverse ground conditions or water or both. The remedial works should be specified by the Maintenance Engineer after an inspection of the site and the necessary investigations.

Dealing with slips and unstable slopes is hazardous and particular care should be taken to safeguard manpower, equipment and the road users.

The principal remedial options are:

- reducing slope angle,
- clearing slip material,
- surcharging the slope,
- gabions,
- cribwork,
- masonry retaining wall,
- concrete retaining wall.

* See *List of Terms, Volume I*.



■ Reducing Slope Angle

Where a cutting face has slipped, one option is to reduce the angle of at least the upper part of the slope. This will increase overall stability and help prevent further slips. **It is often advisable to reduce the slope angle before clearing the existing slip material.**

Care must be taken in case further slippage occurs. A bulldozer may be used if there is access and little risk of causing further slips by this heavy piece of equipment. Alternatively labourers may excavate the material and transport it to a safe dumping site using wheelbarrows.



PART C -ROADSIDE AREAS

■ Clearing Slip Material

This is a **hazardous** activity and should be planned and executed carefully. The slip material should be excavated so that, at all times, the slip and embankment or cutting face are stable.

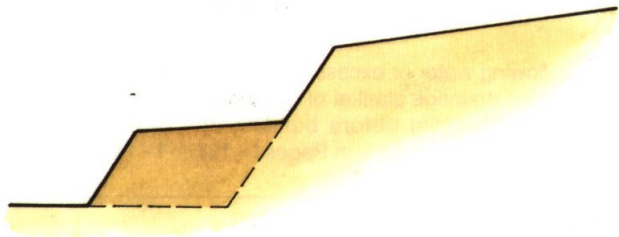
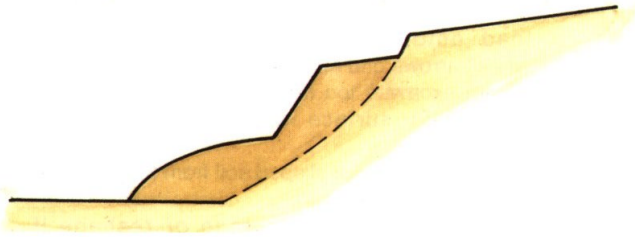
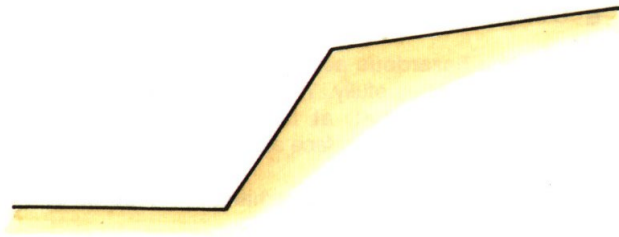
Do not work under an overhanging slope as soil may suddenly slide again.

Excavate soil to reduce the angle at the top of the slope before slip clearing, if possible or necessary.

- excavate all slipped soil from carriageway*, shoulder* and ditch* by loader or by hand,
- load onto trucks, tractor and trailer or wheelbarrows and remove to suitable dump sites,
- do not excavate too deep and damage the road or shoulder surface when using a front-end loader,
- remove last layer of slipped soil from the shoulder or carriageway by hand,
- clear the ditch and regrade or reshape if necessary,
- fine grade the roadway shoulder area with motor or towed grader if available, or by hand,
- if the area requires to be protected from further slipping, the most suitable method can only be determined from site inspection.

If flowing water or excessive moisture is encountered, then a drainage blanket of granular material, or pipes, should be laid before building any of the repair measures described on Pages I - 137 to I - 141.

* See List of Terms, Volume I.



PART C -ROADSIDE AREAS

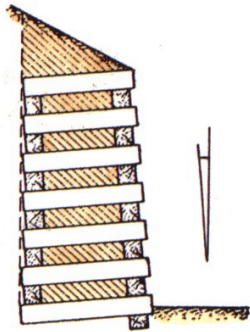
■ Surcharging the Slope

A cutting slope with a wide verge at the base or an embankment slope, may be surcharged to stabilise a slip without removing it. This involves widening the base of the slope by placing material to resist further slipping. The material should be placed in layers of 15 - 20 cms by hand or machine, and compacted with a roller or by hand rammers.

If water or moisture is suspected as a cause of the slip, a drainage blanket of granular material should be laid before placing the fill material. It may also be necessary to excavate counterfort* drains into the slip material to allow water to drain away from the slip face. **Extreme care must be taken when carrying out this activity.**

The final earthworks should be shaped to shed rainwater, and planted if necessary. Certain trees can be planted which will develop root systems to stabilise the slope and reduce underground moisture. Advice should be sought from the local department of agriculture.

* See List of Terms, Volume 1



PART C -ROADSIDE AREAS

■ **Gabions***

A gabion retaining wall may be used to stabilise the base of a slope. The advantages are that the wall can be constructed with relatively unskilled labour, is free-draining and will be flexible enough to allow for further small slip movements.

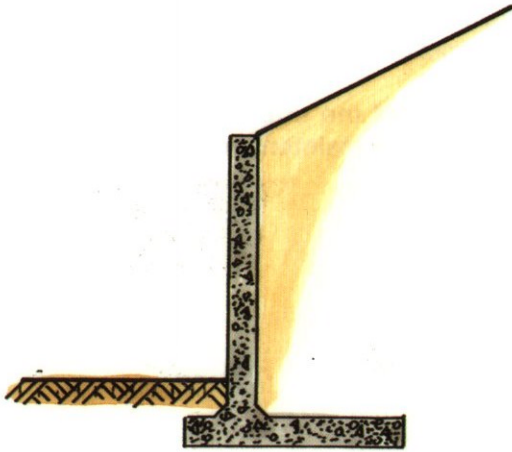
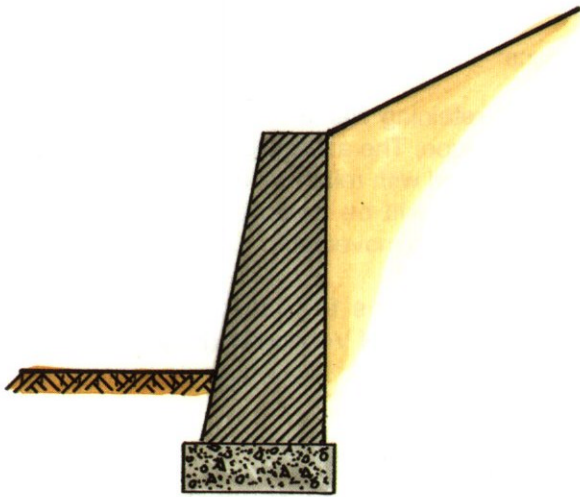
Recommendations for gabion construction are provided in Part A of Volume IV (Pages **IV** - 73 to **IV** -75).

■ **Cribwork***

Retaining walls up to about 5 metres may be constructed using timber or reinforced concrete crib units. The interlocking crib units are laid on a firm foundation with the face sloping back at between 6 to 1 and 8 to 1. The units are fitted with soil (compacted with hand rammers) as the wall increases in height. Cribwork will also allow for further small slip movements and can be rebuilt if necessary.

The design of the crib units and wall should be arranged by the **Maintenance Engineer**.

* See List of Terms, Volume I



PART C - ROADSIDE AREAS

■ Masonry Retaining Wall

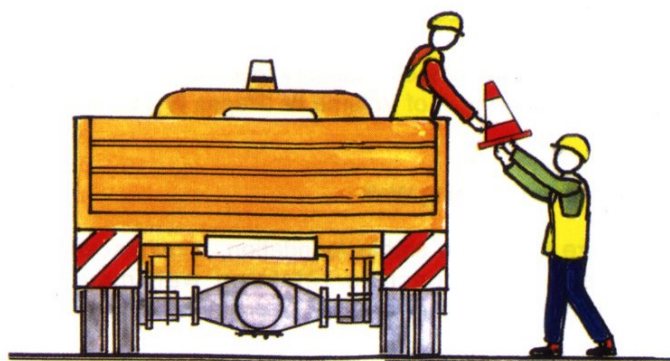
Where there is a stable foundation, a masonry retaining wall may be constructed to retain the base of unstable slopes.

Recommendations on masonry wall construction are provided in Part A of Volume IV (Pages IV - 65 to **IV -67**).

■ Concrete Retaining Wall

Where there is a stable foundation, a reinforced or unreinforced concrete retaining wall may be constructed to retain the base of unstable slopes.

These walls may require specialist skills for design and construction not available in a maintenance department. These should be organised by the **Maintenance Engineer**.

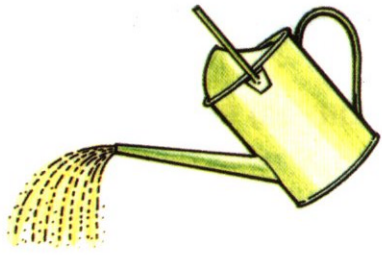


METHOD A: MOBILE GANG

4.4 COMPLETION AND REMOVAL OF TEMPORARY SIGNS

- Load tools, equipment and unused materials back onto the truck or trailer.

- Where they have been used remove the signs, cones and barriers and load them onto the truck or trailer in the following order:
 - 1 "End of Restriction" signs,
 - 2 Traffic cones,
 - 3 "Speed Limit" signs,
 - 4 Barriers,
 - 5 "Road Narrows" signs,
 - 6 "Men Working" signs.



PART C - ROADSIDE AREAS

- Ensure that the site is left clean and tidy with no stockpiles of material left on the shoulder.

- Move onto the next job.

- Inspect traffic signs and clean if necessary.

TYPICAL WORK REPORT

ROADSIDE AREAS

Work Report No: Date:

District: Gang

Zone Road No

Section: from km to km

Location(s):

WORK ACHIEVED:

MANPOWER USED:

Name	Grade	Hours worked
Name	Grade	Hours worked
Name	Grade	Hours worked

EQUIPMENT USED: DIESEL USED:

Hrs	litres
Hrs	litres

MATERIALS USED:

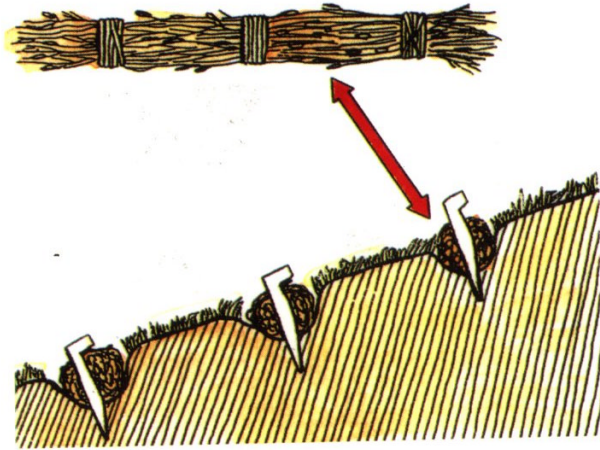
COMMENTS:

Foreman:

4.5 WORK REPORT

The report must be filled in each day, detailing:

- the work carried out,
- the resources used.



PART C – ROADSIDE AREAS

METHOD B: LABOUR BASED

In some road maintenance Systems an individual attendant or lengthman lives close to a road and is responsible for the ROUTINE MAINTENANCE activities on that road.

The following activities are suitable for this method:

REMOVING OBSTRUCTIONS

RESHAPING SHOULDERS

VEGETATION CONTROL (SHOULDERS AND SLOPES)

Furthermore the following PERIODIC MAINTENANCE activities may be carried out by attendants:

ADDING SHOULDER GRAVEL (small scale)

EROSION CONTROL (certain techniques)



METHOD B: LABOUR BASED

5. RESOURCES

5.1 PERSONNEL

- Supervisor
 - foreman or overseer visiting regularly.

- Workforce
 - attendant or lengthman.

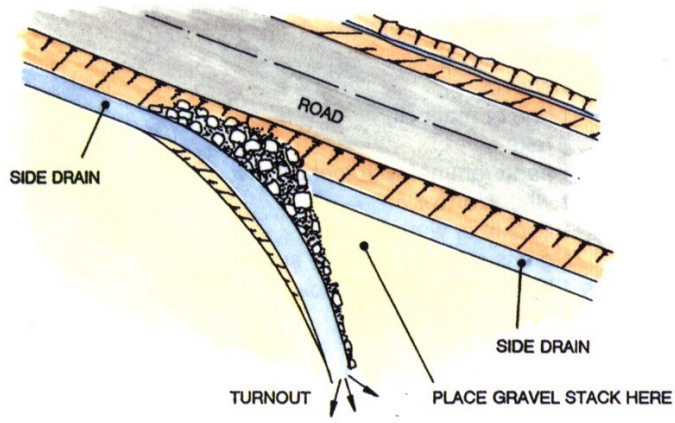


METHOD B: LABOUR BASED

5.2 PLANT AND TOOLS¹

- 1 broom,
- 1 pickaxe,
- 1 shovel,
- 1 hoe or mattock,
- 1 rake,
- 1 hand rammer with metal shoe,
- 1 wheelbarrow,
- 1 bucket or watering can,
- 1 grass slasher, sickle or scythe,
- 1 bush knife or bush hook,
- 1 axe,
- 1 bowsaw,
- 1 file for sharpening tools.

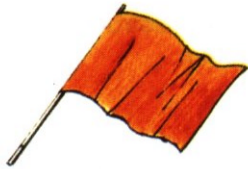
Depending on activities to be carried out.



METHOD B: LABOUR BASED

5.3 MATERIALS

- Gravel for patching shoulders should be obtained from the quarry by truck or tractor and trailer. This is most efficiently done when major regravelling works are being carried out in the area of the road.
- The gravel should be stockpiled at convenient locations where shoulder repairs are expected for the attendant to use on his section of road. The stockpiles must not obstruct the road, the shoulder or the drainage system.
- Where there is no space in the road reserve the stockpile should be placed downhill of a turnout drain to avoid blocking the drainage system.



PART C-ROADSIDE AREAS

METHOD B: LABOUR BASED

5.4 SIGNS AND SAFETY EQUIPMENT

When working on the shoulder the following should be provided.

- **Traffic Signs**

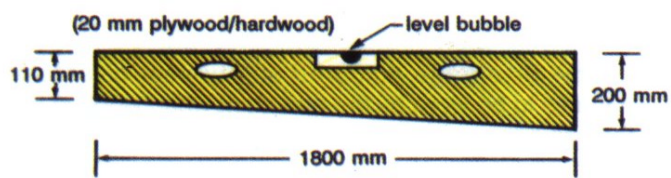
- 2 "Men Working" signs,**

OR

2 yellow/orange flags for placing on the shoulder.

- **Clothing**

- Yellow or orange coloured safety vest or safety harness to be worn by the attendant when working on the shoulder.



METHOD B: LABOUR BASED

6. MAINTENANCE METHOD

6.1 PRELIMINARY TASKS

- The handtools are assigned to the attendant who keeps them at his home for use as necessary.
- The worksheet will indicate the location and extent of the work to be carried out and the time required for the job.



PART C - ROADSIDE AREAS

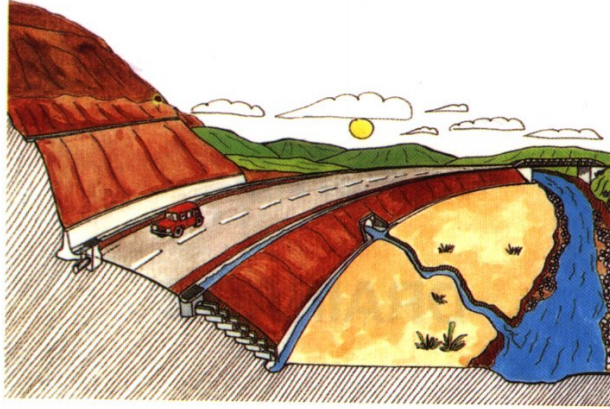
METHOD B: LABOUR BASED

6.2 EXECUTION OF THE WORK

- The attendant should use the wheelbarrow to carry the tools and safety items to the site.
- The warning signs or flags must be placed either side of the worksite.
- The attendant should use the wheelbarrow to transport the gravel material from the stockpiles to the "Adding Shoulder Gravel" site.
- The tasks should be carried out as described for the Mobile Gang.
- The warning signs or flags must be removed after the work.
- The work report must be filled in for each day's work.

Part D

DRAINAGE



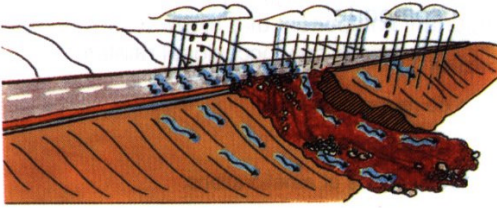
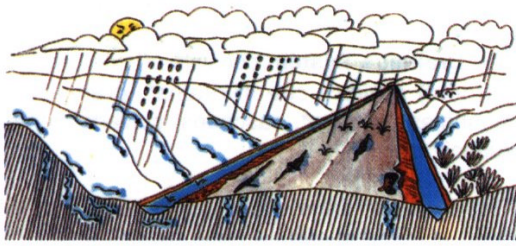
1. THE TASK

- The Drainage System consists of side drains*, mitre (turnout) drains*, cut-off drains*, drainage pipes*, manholes*, chutes*, cascades, culverts*, drifts* and subsoil* drains.

The purpose of the system is to rapidly collect and conduct rain and ground water away from the road.

Water can cause widespread damage to the road by weakening the pavement* or foundations, and erosion. The **Drainage System** is therefore the most important component of a highway or rural road, even in locations with only occasional rainfall.

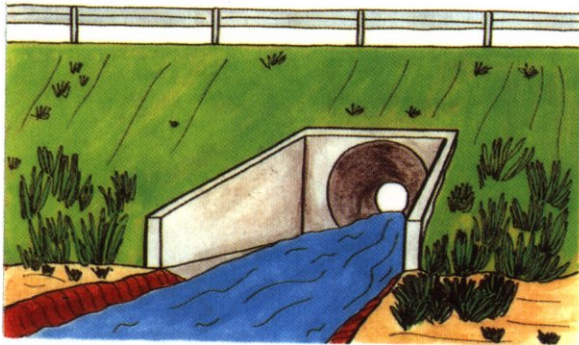
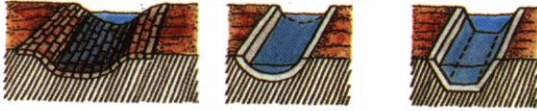
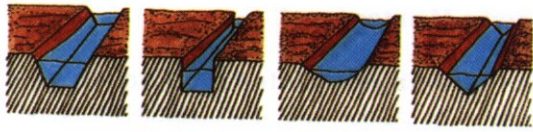
* See List of Terms, Volume I



PART D - DRAINAGE

- **The Routine Maintenance*** of the drainage system is essential to preserve the road structure and running surface. Occasionally major repairs or improvements are required to be carried out under **Periodic Maintenance***.
- Most **Drainage** maintenance activities can be achieved by labour, and are suitable for being carried out by a mobile or local gang, or by an individual attendant or lengthman living close to the road.
- For the descriptions in this Part D (Drainage), it is assumed that all vegetation has been removed from the area around drainage features to enable drainage maintenance to be carried out. Vegetation control tasks are described in Part C of this volume.

* See *List of Terms, Volume I*



1.1 OBJECTIVE

■ Water can seriously damage any road

It can

- erode soils,
- weaken pavements*,
- destroy shoulders* and slopes*,
- wash-out culverts*, embankments* and even bridges*

The satisfactory operation of the drainage system is therefore a vital condition for a satisfactory road.

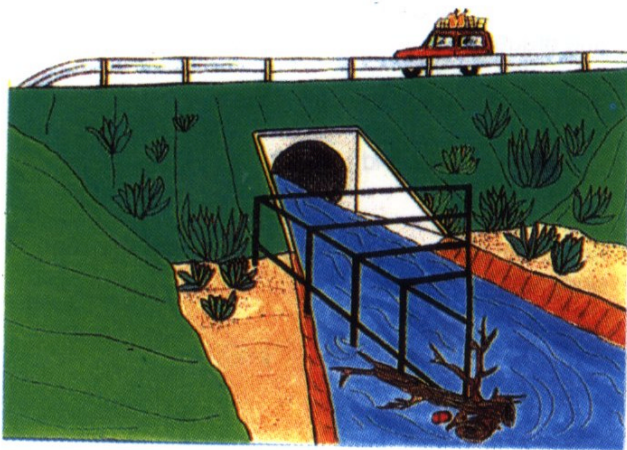
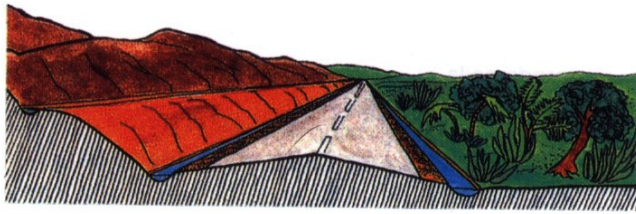
- The OBJECT of maintenance is to ensure that drainage system elements remain free of obstructions, and retain their intended cross-sections and grades.

They must function properly so that

- surface water and
- groundwater

can drain freely and quickly away from the road or under the road.

**See List of Terms, Volume I*



PART D - DRAINAGE

1.2 ACTIVITIES

1.2.1 Ditches* and Drains*

Routine* Activities

- CLEARING AND CLEANING
- RESHAPE/REGRADE/DEEPEN
- EROSION CONTROL
- a) Regrade/Realign Drains
- b) Repair Lining
- c) Provide/Repair Scour Protection

Periodic* Activities

- PROVIDE NEW MITRE (TURNOUT) DRAIN
- EROSION CONTROL
- a) (Re)Line Drain
- b) Construct Cascade/Catchpit
- c) Construct Flow Spreader

1.2.2 Culverts*

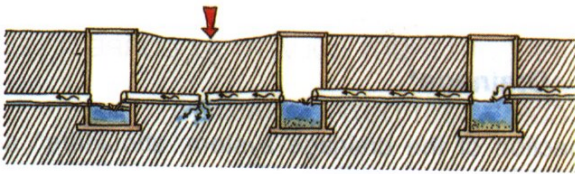
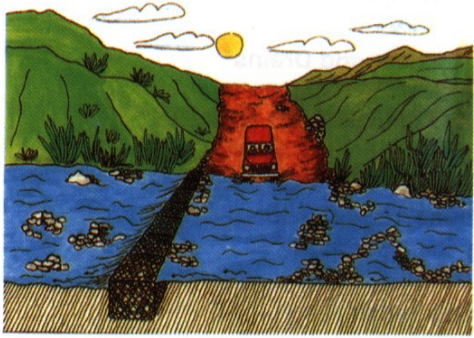
Routine Activities

- CLEARING AND CLEANING
- EROSION REPAIR
- CRACKING REPAIR
- HEADWALL/APRON REPAIR

Periodic Activities

- REPAIR OF INVERT
- (RE)CONSTRUCT CULVERT AT CORRECT LEVEL AND FALL
- CONSTRUCT OUTFALL BASIN*

* See List of Terms, Volume I.



PART D - DRAINAGE

1.2.3 Drift* and Causeways*

Routine* Activities

- MINOR REPAIRS
- GRADING/CLEARING
- REPLACE GUIDE-POSTS

1 .2.4 Manholes* and Drainage Pipes*

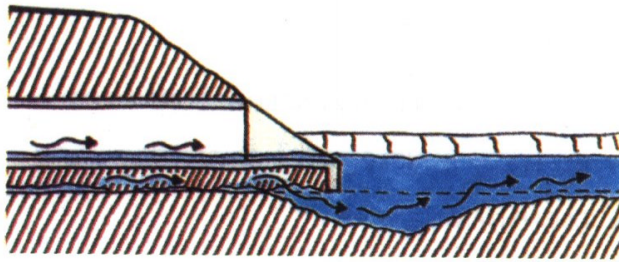
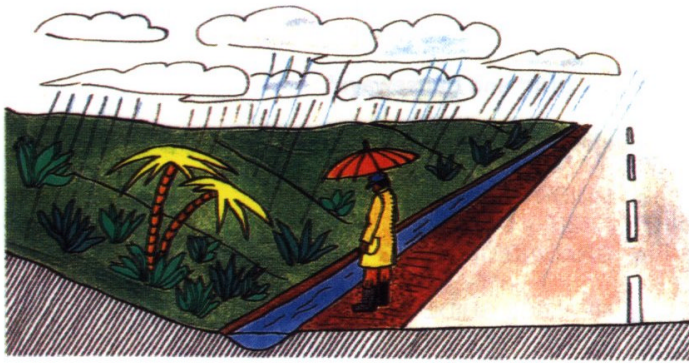
Routine Activities

- CLEAR MANHOLE AND UNDERGROUND PIPES
- REPLACE MANHOLE COVER OR GRATING
- CLEAR MANHOLE AREA
- CLEAN CATCHPIT SUMP

Periodic Activities

- RELAY DRAINAGE PIPE

** See List of Terms, Volume I.*



2 DEFECTS

2.1 LIST OF DEFECTS

On the following pages commonly occurring defects are shown. Their probable causes are given together with a suggested maintenance activity. In addition the results of neglected repair are mentioned:

- **Defect**
- **Main causes of the defect**
- **Development:** consequences if maintenance is not rapidly carried out
- **Remedies:** usual repair treatments.



2.2 DITCHES* AND DRAINS*

DEFECT: OBSTRUCTIONS

Main Causes

- vegetation growth, bushes, fallen trees, debris, loose silt, loose rocks.

Development, if neglected

- blockage of ditch.

Remedies

- clearing and cleaning.

DEFECT: SILTING

Main Causes

Invert* slope is too flat, the water cannot flow at sufficient speed.

Development, if neglected:

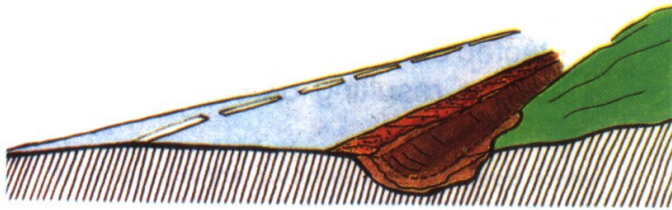
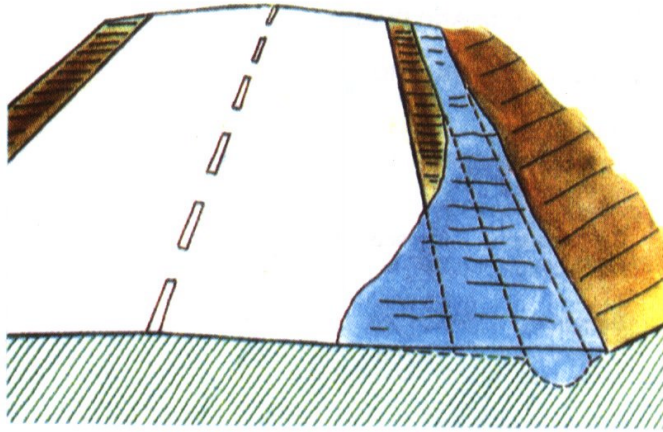
- Blockage of the ditch.

Remedies

- deepen ditch (desilting), and/or provide new mitre drains (turnouts),

where deepening or turnouts are not possible because of topography, the construction of a new culvert* with a drop-inlet may be possible, in order to discharge water onto the other side of the road.

** See List of Terms, Volume I.*



DEFECT: PONDING IN DITCH AND ON SHOULDER

Main Causes

- the ditch cross-section is too small,
- the ditch gradient is too flat.

Development, if neglected

The shoulder material becomes soft and can easily erode. The pavement* can also be flooded and thereby weakened.

Remedies

- deepen ditch,
- provide new mitre drain.

**DEFECT: DITCH CROSS-SECTION IS DESTROYED
(UNLINED DITCH)**

Main Causes

- vehicular or animal traffic, cave-in.

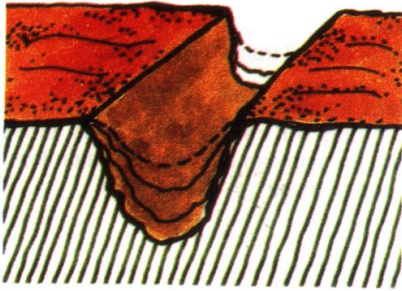
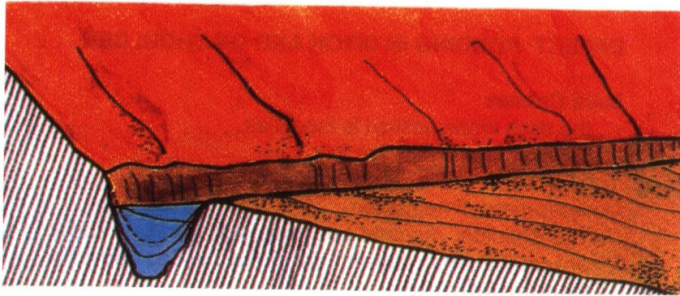
Development, if neglected

Partial silting will result if the ditch sides have collapsed. Erosion can start where water flow passes the blocked section.

Remedies

- reshape/regrade ditch, line drain.

* See List of Terms, Volume I.



DEFECT: INVERT* AND SIDES OF DITCH* ARE ERODED

▪ **Main Causes**

Invert slope is too steep.

▪ **Development**, if neglected

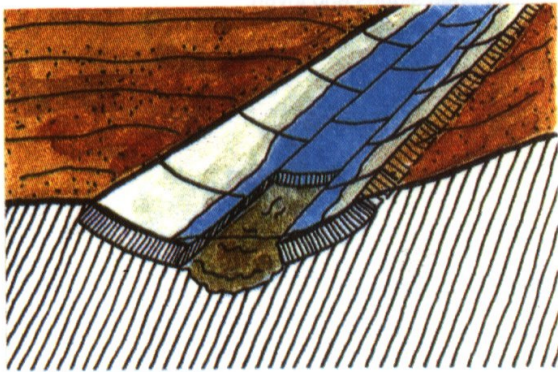
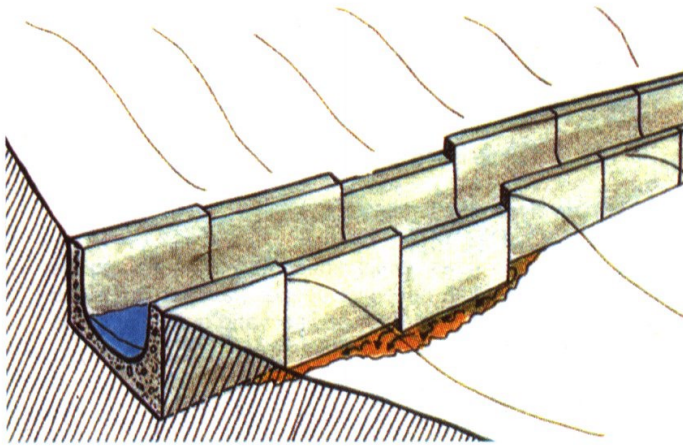
The water flows at high speed and starts eroding the soil. The ditch becomes deeper (ravine). The sides then cave-in, the road shoulder and even part of the carriageway* can be washed away.

▪ **Remedies**

Erosion control:

- Regrade/realign drains,
- provide repair scour protection,
- line drain slopes and invert,
- construct cascade.

* See List of Terms, Volume I



DEFECT: DITCH* LINING IS DAMAGED

▪ **Main Causes**

- poor construction workmanship,
- soil settlement, erosion of soil under ditch lining,
- poor alignment or sudden change in flow direction.

▪ **Development, if neglected**

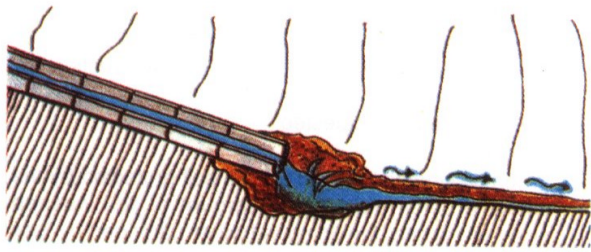
When flowing water reaches the soil protected by the lining,. erosion starts. The amount of soil washed away increases, the lining is further damaged by loss of support, leading to complete destruction of the lining.

▪ **Remedies**

Erosion control:

- repair lining,
- realign drain.

* See List of Terms, Volume I



DEFECTS: EROSION AT DRAIN OUTFALL*

Main Causes

- flow too fast,
- flow too concentrated,

for the soil at the outfall to resist.

Development, if neglected

Erosion will continue back into the ditch and increase in the area of the outfall. The erosion may eventually threaten the road as well as the surrounding land.

Remedies

Reduce water flow and speed by:

- realign drain to flatter gradient,
- provide new mitre drain, upstream from existing.

Reduce impact at outfall by:

- construct cascade,
- construct flow spreader.

Erosion Control for the soil:

- turfing,
- wattling,
- stone pitching.

** See List of Terms, volume I*



2.3 CULVERTS*

DEFECT: **SILTING, SANDING, BLOCKAGE BY DEBRIS**

Main Causes

- Invert* slope too flat,
- culvert constructed too low, so that material from the stream bed becomes deposited in the culvert,
- vegetation and floating debris carried by water have become lodged in the culvert.

Development, if neglected

The intended waterway opening will be so reduced that flood water cannot flow. It will back-up or pond on the upstream side of the culvert and may eventually over-flow the road embankment*. The road is then in danger of being washed away.

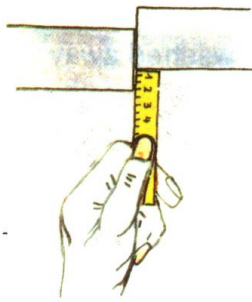
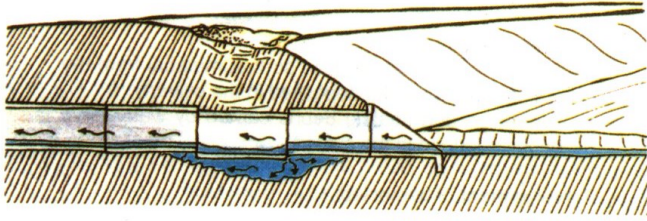
Remedies

- clearing and cleaning,
- if floating debris is a problem, the provision of a debris rack* should be considered.

If the culvert regularly silts up:

- reconstruct at correct level and fall.

See List of Terms, Volume I.



DEFECT: SETTLEMENT CRACKS

Main Causes

Settlement of soil below culvert*.

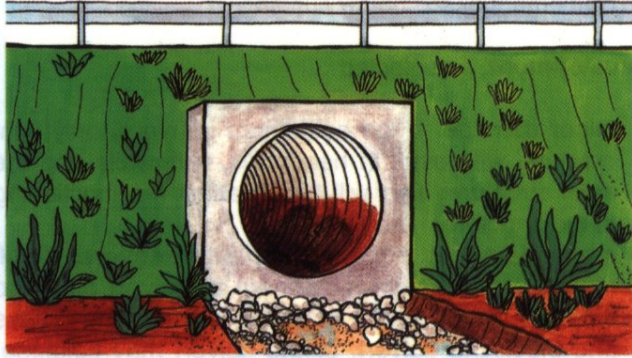
Development, if neglected

- minor damage: If the settlement is minor, only light cracking will result in headwalls, wingwalls and the main structure. This will hardly affect the functioning of the structure,
- major damage: If the settlement is severe, it will cause large relative movement of culvert pipes so that embankment soil will enter through the cracks and block the culvert, or the culvert may collapse. The culvert must then be reconstructed.

Remedies

- cracking repair,
- reconstruct at correct level and fall.

* See *List of Terms Volume I*.



PART D - DRAINAGE

DEFECT: THE STEEL CULVERT INVERT' IS DAMAGED BY RUST

Main Causes

- poor quality galvanising or surface protection,
- protective surfacing worn away by water flow,
- weathering (after long service life).

Development, if neglected

Severe damage to structure invert, probable partial or complete collapse of the structure.

Remedies

- repair of invert,
- reconstruct at correct level and fall.

**See List of Terms, Volume I.*



DEFECT: EROSION OF STREAM BED AT CULVERT OUTLET

Main Causes

- the culvert invert has been constructed too steep so that the water flows too fast,
- the culvert invert has been constructed too flat with an excessive drop at the outfall (these are design or construction mistakes).

Development, if neglected

The stream bed is washed away and a pool or ravine develops. The culvert downstream head and wingwalls* and even a section of the culvert and road embankment can collapse into the pool or ravine.

Remedies

- erosion repair,
- construct outfall basin*.

DEFECT: MINOR HEADWALL/APRON* DAMAGE

Main Causes

- minor settlement,
- scour or erosion.

Development, if neglected

- erosion at the headwall/apron,
- culvert blockage or collapse.

Remedies

- headwall/apron repair.

* See List of Terms, Volume I.



2.4 DRIFTS AND CAUSEWAYS*

The surfaces of submersible crossings are often constructed as a concrete slab. There is a high risk of washouts and slab movement caused by the water turbulence. Routine* maintenance should correct any minor defects as they occur, to avoid later extensive and costly major works.

The **Routine*** activities can include concrete or masonry repair, placing of gabions* and erosion protection of causeway* openings as in the case of culverts.

DEFECT: MINOR DEFECTS

Main Causes

- settlement of slab,
- erosion.

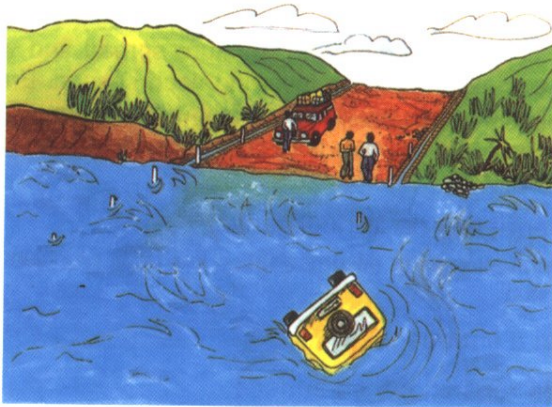
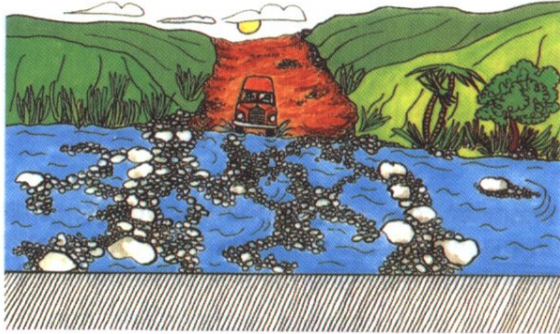
Development, if neglected

The cracks in the drift* structure spread and widen especially during the following flood season. Erosion will undermine the drift. The drift will break up.

Remedies

Minor repairs.

* See List of Terms, Volume I.



PART D - DRAINAGE

DEFECT: DRIFT* OR CAUSEWAY* IS COVERED WITH DEBRIS

Main Causes

Natural movement of river bed material by flowing water.

Development, if neglected

The limits of the paving cannot be seen; vehicles may drive onto loose river bed material at the edge of the drift and become damaged or immobilised.

Remedies

Grading/Clearing drift surface. The surface must be cleared of all loose material.

DEFECT: GUIDE-POSTS (MARKERS) ARE MISSING OR DAMAGED

Main Causes

Accident, flood damage, vandalism.

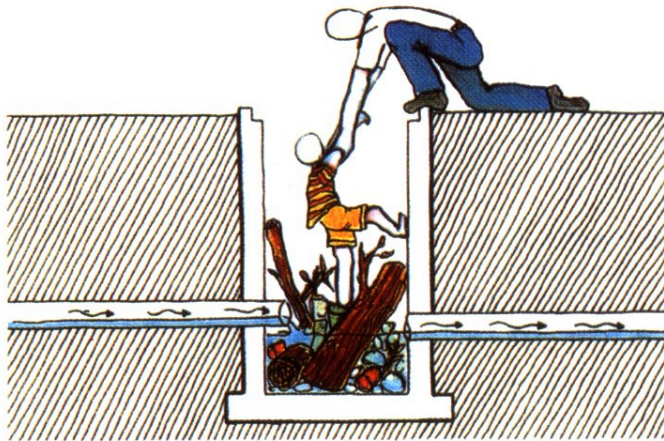
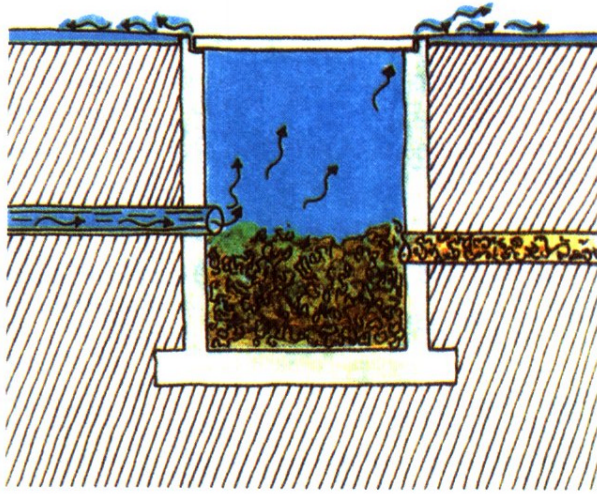
Development, if neglected

When the drift or causeway becomes submerged during flood, the edge of the pavement cannot be seen. Vehicles can accidentally drive into deep water.

Remedies

Replace guideposts.

**See List of Terms, Volume I*



PART D - DRAINAGE

2.5 MANHOLES* AND DRAINAGE PIPES*

DEFECT: WATER IS FLOWING UP AT MANHOLE

Main Causes

The manhole or connected underground pipes are blocked and water cannot flow as intended.

Development, if neglected

- flooding of road shoulder* or carriageway*
- drainage system becomes ineffective, danger of earth slip or weakening of pavement*.

Remedies

Clear manhole and underground pipes.

DEFECT: MANHOLE COVER OR GRATING IS MISSING/DAMAGED

Main Causes

Accident, vandalism.

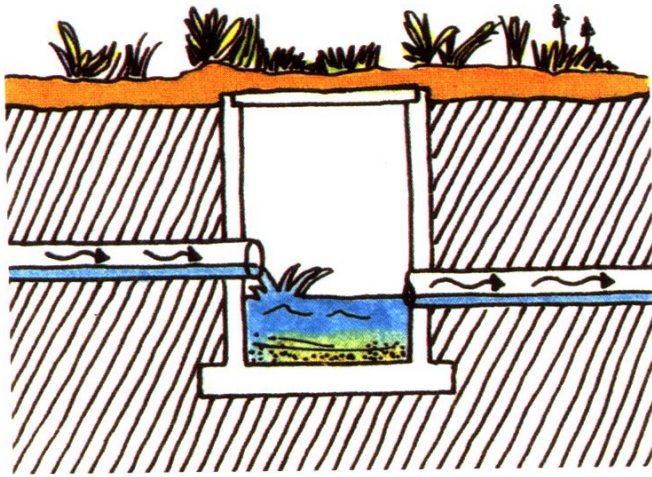
Development, if neglected

Open manholes become a danger to people and animals. Vegetation and debris have uncontrolled access and blockage can occur.

Remedies

Replace manhole cover or grating.

* See List of Terms, Volume I.



DEFECT: THE MANHOLE* IS COVERED WITH SOIL AND VEGETATION

Main Causes

Silting of the ground area at manhole; manhole cover level possibly set too low.

Development, if neglected

Possible blockage of the drainage system at the manhole, due to an undetected accumulation of silt in the manhole.

Remedies

Clear manhole area.

DEFECT: THE CATCHPIT* SUMP IS COMPLETELY SILTED UP

Main Causes

Silt and debris collecting in the sump has not been removed sufficiently regularly.

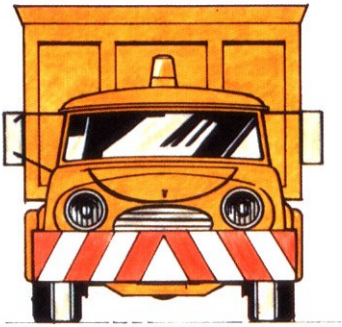
Development, if neglected

Possible blockage of the drainage system at the catchpit, or down stream due to a build up of silt or debris.

Remedies

Clean catchpit sump.

* See List of Terms, Volume I



3. RESOURCES

The following recommendations relate to carrying out the work using a mobile gang.

Where appropriate options for equipment or labour methods are described.

Reduced transport resources will be required if the work is carried out by a local gang, with labourers walking to and from work each day.

The gang size and other resources may be varied depending on the type and number of activities, the quantity of work to be achieved, and the resources available.

Many of the activities described can be carried out by an attendant or lengthman. This approach is described in Pages I – 28 to I -299.



3.1 PERSONNEL

From the following resources.

■ Supervisors

- 1 foreman or overseer visiting regularly,
- 1 headman for each 10 to 20 workmen.

■ Plant Operators and Drivers

- 1 light vehicle driver (for foreman or overseer)¹,
- 1 tipper/flat bed truck driver²,
- 1 tractor-trailer driver³,
- 1 tractor driver and 1 towed grader operator, or 1 motorgrader operator⁴.

■ Workforce

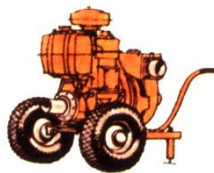
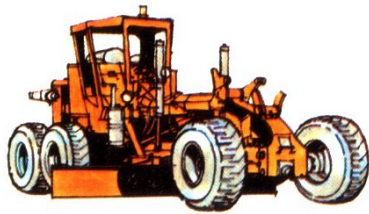
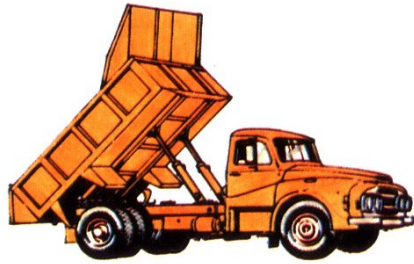
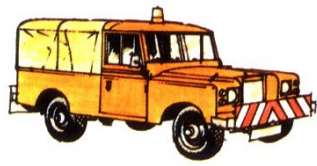
- 1 to 2 masons,
- 10 to 20 workmen.

¹ If a light vehicle is used.

² (f **B** mobile gang is used, or for materials/debris transport.

³ Alternative for transporting materials up to about 10 km, or debris.

⁴ (f drains are cleared/reshaped by mechanical methods.



3.2 PLANT AND TOOLS

- 1 light vehicle or motorcycle,
- 1 tipper/flatbed truck or tractor-trailer (part-time) ¹,
- 1 tractor and towed grader, or 1 motorgrader²,
- 1 water pump ³,
- 1 hand winch³.

1 For transporting mobile gang or transporting debris or materials.

2 If drain cleaning/reshaping is mechanised.

3 For culvert/pipe repair work.

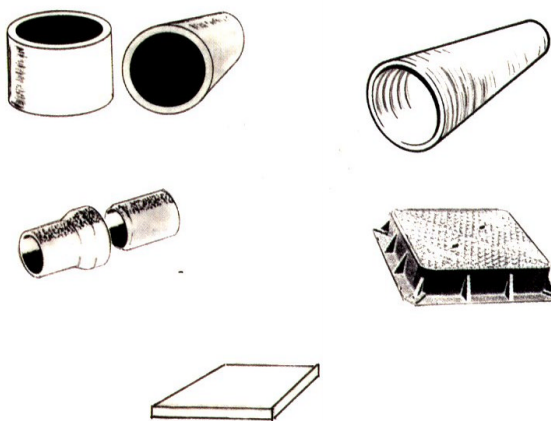
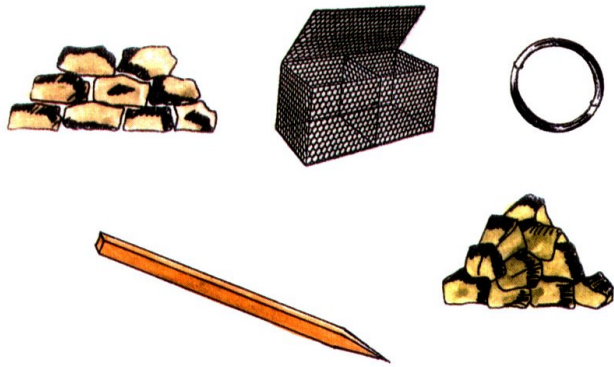


DRAINAGE

- **Small items of Equipment¹**

- | | |
|---|--|
| - 1 hoe for every workman, | - rods and fittings for clearing pipe drains, |
| - 1 shovel for every workman, | - 5 buckets, |
| - 5 mattocks for every 10 workmen, | - manhole cover lifting keys, |
| - 5 slashers, | - 1 spirit level, |
| - 5 rakes, | - 1 line and level or abney level, |
| - 5 bushknives, | - 1 ditch template and spirit level, |
| - 2 sledgehammers, | - 5 ranging rods and profiles, |
| - 4 handhammers, | - 2 mason's hammers, |
| - 2 brooms, | - 2 club hammers, |
| - 2 pickaxes, | - 2 mason's chisels, |
| - 2 crowbars, | - 2 mason's trowels, |
| - 2 bow saws, | - 2 pointing trowels, |
| - 2 brush hooks, | - 2 mason's floats, |
| - 2 axes, | - 2 straight edges (2 metre), |
| - 5 wheelbarrows, | - 2 measuring tapes (30 metre), |
| - carpenter's saws, | - 2 folding rules (2 metre), |
| - 2 claw hammers, | - 2 plumb bobs, |
| - 2 mallets, | - 2 setting out strings, |
| - 2 chisel sets, | - 2 hand brushes |
| - 2 files (for sharpening tools), | - aggregate measuring box (equivalent to 1 bag of cement). |
| - 1 plate compactor, | |
| - ropes for controlling culvert components, | |
| - assorted nails and pegs, | |
| - long handled shovel/spike for culvert cleaning, | |

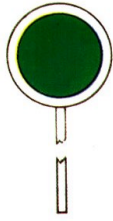
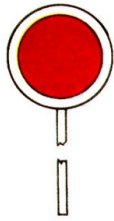
¹ Depending on activities to be carried out.



3.3 MATERIALS¹

- A source of water will be needed as near as possible to the site for masonry repairs.
- Materials for culvert, drift, manhole or pipe repairs, according to local construction methods:
 - aggregates, sand, cement,
 - plastic sheet to protect cement,
 - masonry stone or brick or blocks,
 - gabion wire baskets,
 - 3 mm binding wire,
 - wooden stakes,
 - gabion filling stone,
 - concrete culvert rings,
 - corrugated steel culvert rings and fittings,
 - drainage pipes,
 - manhole covers,
 - jute or plastic sacks for sandbags,
 - drain lining tiles.

¹ Depending on activities to be carried out
*See List of Terms, Volume I.



2



2



1



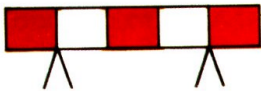
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2



2



2



3.4 SIGNS AND SAFETY EQUIPMENT

Drainage activities do not usually involve work on, or the need to close, all or part of the road carriageway or shoulder.

Where occasionally such works are required (e.g. relaying a cross culvert), then Signs and Safety Equipment suitable for Bridgeworks should be used (Volume **IV**, Part A, Pages **IV** - 27 to 29).

TYPICAL WORKSHEET

DRAINAGE

Worksheet No:

Date:

District:

Zone:

Gang:

Road No

from

to

Location(s):

Work to be carried out:

Work to be completed by:

(Date)

Signed:

METHOD A: MOBILE GANG

4. MAINTENANCE METHOD

4.1 PRELIMINARY TASKS

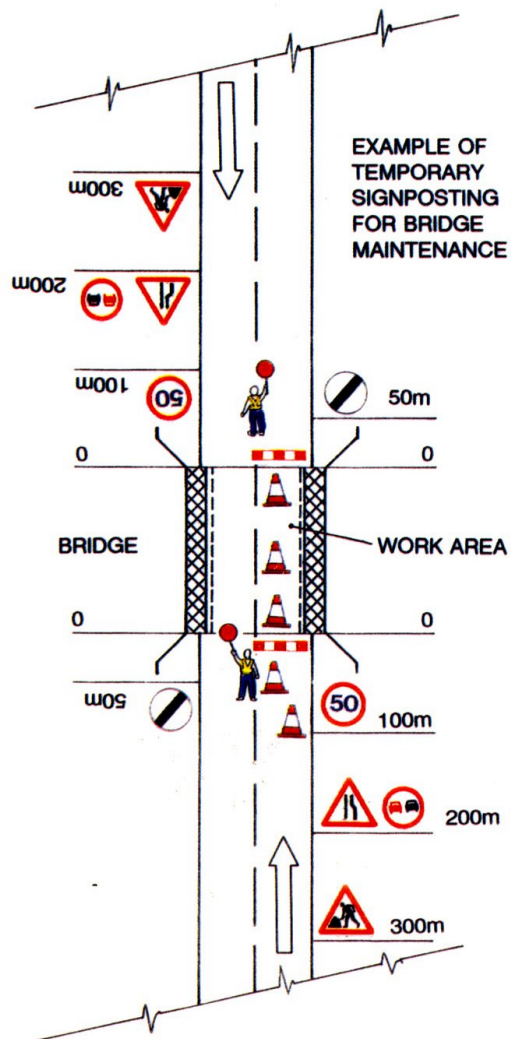
- **The Worksheet** will indicate the location and extent of the work to be carried out and the time, equipment and personnel required for the job.



PART D - DRAINAGE

Before setting out to start the job, a check should be made to ensure that everything needed is ready.

- **The Truck, tractor and trailer**, or other plant must be fuelled, checked mechanically and have water and oil levels checked.
- **Traffic signs, barriers and cones** must be obtained and loaded onto the truck or trailer, if work is required on the carriageway or shoulders.
- **Tools, small equipment and materials**, must be obtained and loaded onto the truck or trailer.
- Arrangements must be made for obtaining water for culvert or pipe repairs.

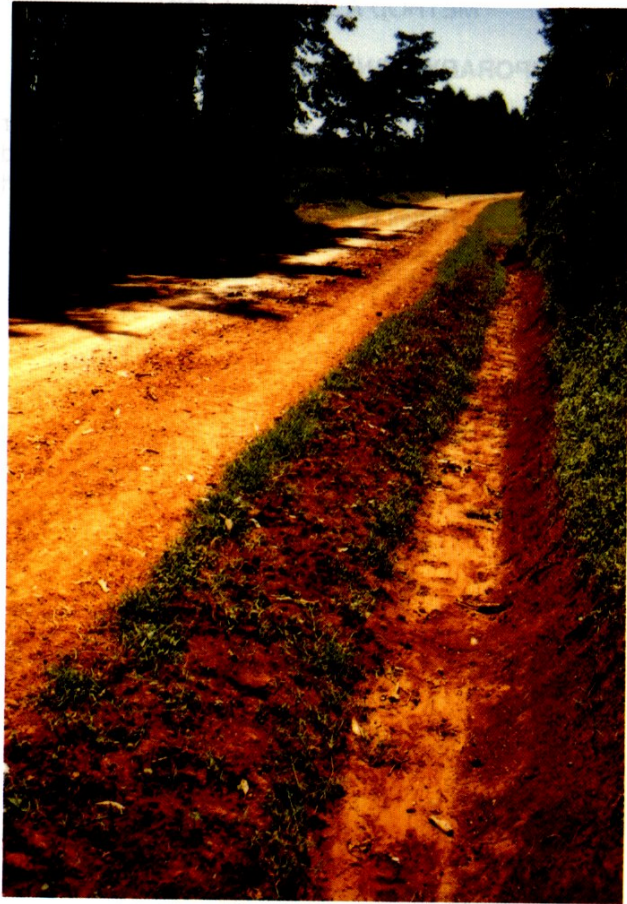


NOTE: SHOWN FOR DRIVING ON THE RIGHT

METHOD A: MOBILE GANG

4.2 TEMPORARY SIGNPOSTING

Where work is required on the road carriageway or shoulders, signs should be provided and placed according to the recommendations of Volume IV, Part A - Bridges, Pages IV - 35 to 37.



METHOD A: MOBILE GANG

4.3 EXECUTION OF THE WORK

Ditches and Drains

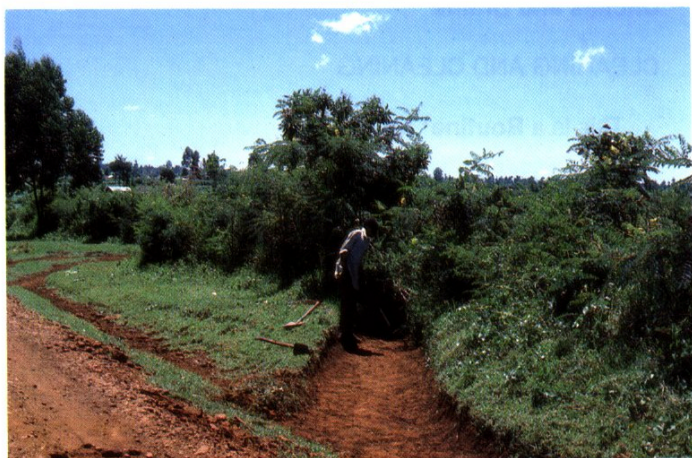
CLEARING AND CLEANING

This is a Routine* activity.

The object is to remove all soil, high vegetation, materials and objects from the ditch* which could possibly interfere with water flow or cause an eventual blockage of the ditch. This can include for example, rocks, loose silt and sand, weeds, trees, bushes, including their roots, etc. Dispose of these materials well away from the roadside so that water flow will not be impeded and **they will not fall or wash back into the drain.**

On unlined ditches a short grass cover can help to stabilise the invert* and sides of the drain. Therefore where a side drain is established to the correct depth and profile with grass cover and no erosion, it is advisable to merely cut the grass short. This will leave the roots in place to bind the surface together.

*See *List of Terms, Volume I.*



Ditches and Drains

RESHAPE/REGRADE/DEEPEN

This is a **Routine*** activity that can be carried out by labour methods. In some locations it may be carried out by mechanised methods.

a) Labour Method

The object is to remove material from the ditch to obtain the correct cross-section and grade.

It is advisable to adopt a trapezoidal ditch shape when using labour methods. The excavation using a hoe/mattock and shovel is easier than for a V-shaped ditch. An added advantage is that the flat invert causes less concentration of water than a V-ditch.

A ditch template* should be used to obtain the correct drain shape.

- using the template a 50 cm wide slot* should be excavated to the correct ditch shape every 10 metres. The slots act as a guide for excavating the ditch to the correct shape,
- in flat areas, the gradient of the ditch should be checked using ranging rods and profiles or similar methods, to ensure that water will not pond. The levels at adjacent slots should be checked using a line and level or abney level*, and the level of the slot adjusted if necessary.

**See List of Terms, Volume I.*



PART D - DRAINAGE

- excavate all surplus material between the slots and to the correct shape with the aid of stringlines stretched between the slots. If necessary the intermediate invert levels can be checked using a traveller* sighted between the ranging rod profiles.
- material excavated from the drain must be removed and spread well clear of the drain so that it cannot later fall or wash back into the ditch.
- the shape can be checked during the excavation activity using the ditch template*.

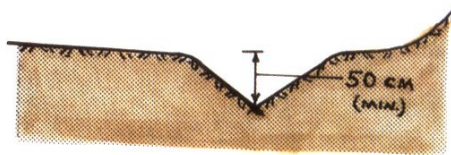
When excavating a completely new ditch it is preferable to split the task into two operations:

- i. cut the central rectangular shape and check with a template (INVERT).
- ii. cut the slopes and check with the full template (SLOPES).

The alignment or route of the drain should be set out using stringlines and pegs.

The ranging rods and profiles should be set up at the start and outfall* of the ditch. Intermediate profiles may be required on long ditches. The levels of intermediate slots can be determined using the traveller.

*See List of Terms, Volume I.



PART D – DRAINAGE

b) Mechanised Method

This activity is suggested where long sections of V-shaped ditches* are to be maintained and cleaned and where high daily outputs are possible. The activity may be carried out by a motor or towed grader. The grader should always work in the direction of water flow in the ditch.

Case 1:

When the grader can operate only on the shoulder* and in the ditch, but not beyond the ditch:

- start by grading the **outside slope*** of the ditch, windrowing the soil to the bottom of the ditch between the rear wheels. (This can be repeated to obtain the desired depth of ditch),
- the second pass* cleans the invert* of the ditch by removing the windrow to the top of the ditch at road shoulder,
- the third pass is required to move the windrow material away from the shoulder ditch edge.

THE MATERIAL MUST BE REMOVED FROM THE SITE.

UNDER NO CIRCUMSTANCES IS THE MATERIAL TO BE SPREAD ON THE ROAD.

**See List of Terms, Volume I.*

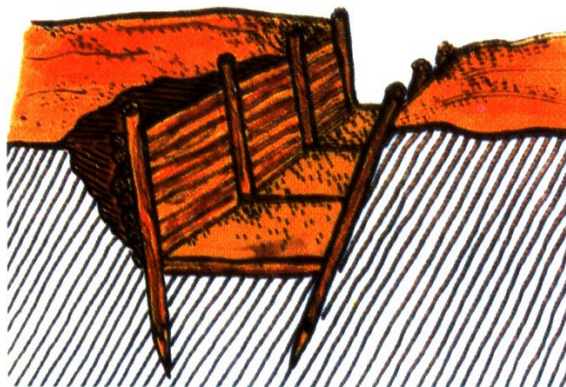
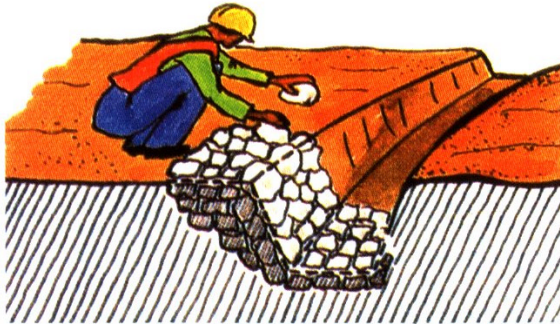
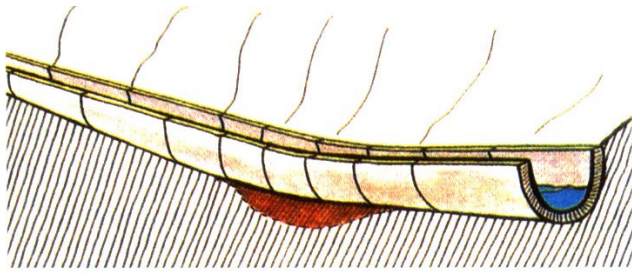


PART D - DRAINAGE

- on completion, the ditch should generally have a depth of 50 cm (minimum), which can be checked with a ranging rod and tape/rule,
- if necessary the grade of the ditch invert can be checked using the methods described in a) Labour Method (Page I - 223).

Case 2:

- When the grader can operate beyond the ditch. Reverse the operations shown previously:
- grade the **inside slope**, windrowing material to the bottom of the ditch. Repeat as necessary to achieve the desired depth of ditch,
- remove the windrow material to the top of the outside slope,
- move windrow away from ditch edge and spread the material so that it will not wash back into the ditch,
- on completion, the ditch should have a depth of 50 cm (minimum), which can be checked with a ranging rod and tape/rule,
- if necessary the grade of the ditch invert can be checked using the methods as described in a) Labour Method (Page I - 223).



PART D - DRAINAGE

Ditches and Drains

EROSION CONTROL

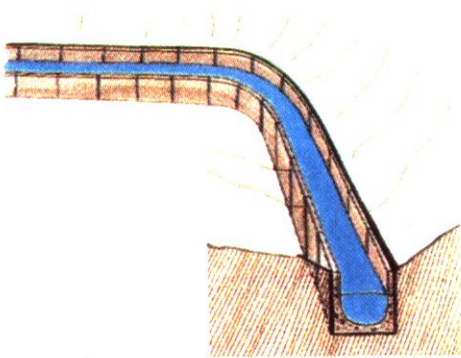
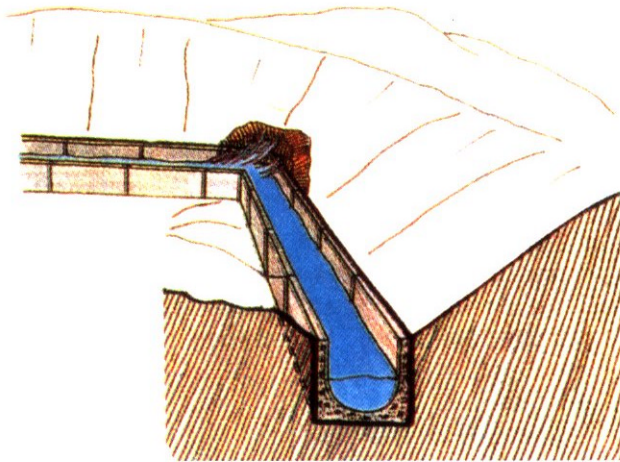
A number of Routine* activities are possible to prevent or repair erosion damage to ditches* and drains*

Drain sections are often laid at a steep gradient or on sharp bends without erosion protection along or at the outfall of the drain. The following options should be considered:

- a) Regrade/Realign Drains
- b) Repair Lining
- c) Provide/Repair Scour Protection

If these **Routine*** activities are inadequate, then consideration should be given to the **periodic*** activities described on Pages I - 241 to I - 247.

**See List of Terms, Volume I*



PART D - DRAINAGE

a) Regrade/Realign Drain

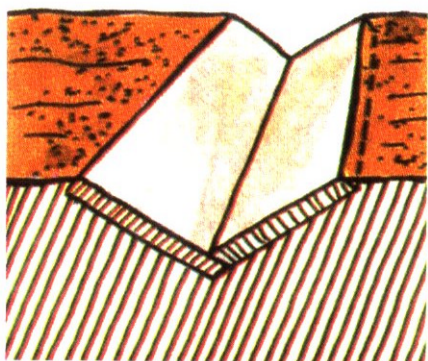
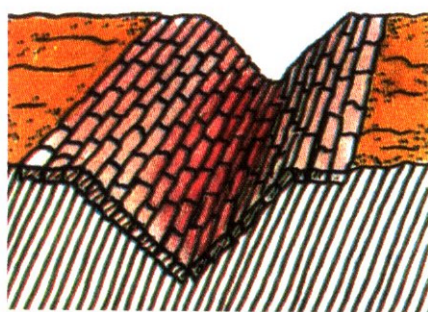
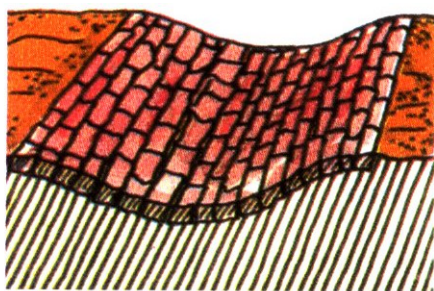
- the drain* may be extended with a flat outfall to reduce the speed of the water when leaving the ditch. The gradient should ideally be between 2% and 5%,
- the drain could be realigned to follow the contour lines more closely, until a location is reached where it may safely discharge.

Both of the above options should use the techniques described under **Reshape/Regrade/Deepen** Pages I - 223 to I - 229.

Water cannot flow smoothly around sharp bends. The result is usually a collapse of drain sides. The following repair measures are suggested:

- relay drain sections to a smooth easy curve and grout smooth any open joints, or
- install special precast curved ditch sections.

**See List of Terms, Volume I*



PART D - DRAINAGE

b) Repair Lining

Ditches* lined with masonry or other material need repair when the lining is damaged. The cause of such damage is usually **settlement** of the supporting soil.

The repair work is to be carried out as soon as possible as the ditch can be quickly destroyed if water can flow under or behind the lining.

The procedure is:

- remove settled or damaged precast sections or loose stone blocks,
- compact the underlying soil,
- backfill with suitable material and compact to correct levels,
- replace the precast sections or blocks to the correct line and grade, bedding them on mortar (1 cement : 4 sand),
- grout up any open joints with mortar,
- remove all debris.

**See List of Terms, Volume I.*



PART D - DRAINAGE

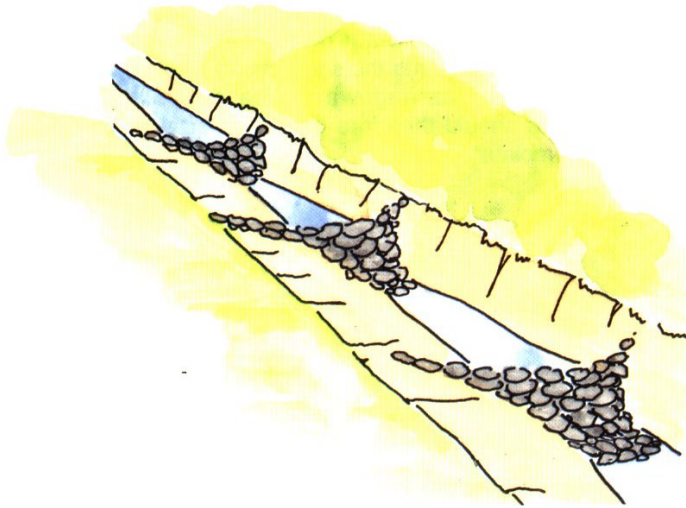
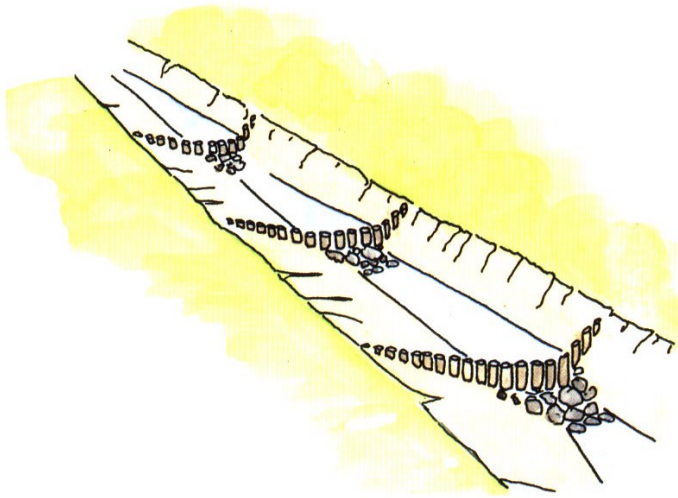
c) Provide/Repair Scour Protection

Unlined ditches* may suffer from scour of the invert and sides.

- simple repairs may be achieved by fillin~ the affected areas with soil and ~ where climatic conditions are favourable. The turves will probably need to be pegged in place to retain them, and watered until established,
- simple scour checks may be constructed of wood or stones. Larger ones may be constructed of stone masonry, brick or concrete. They reduce the speed and erosion force of the water. They also hold back the silt carried by the water flow to provide a series of gently sloping sections of ditch separated by steps.

The scour checks must not be too high otherwise water will be forced onto the surrounding ground, the shoulder* or the ~ The scour check construction should therefore be controlled with the aid of a template*.

**See List of Terms, Volume I*



PART D - DRAINAGE

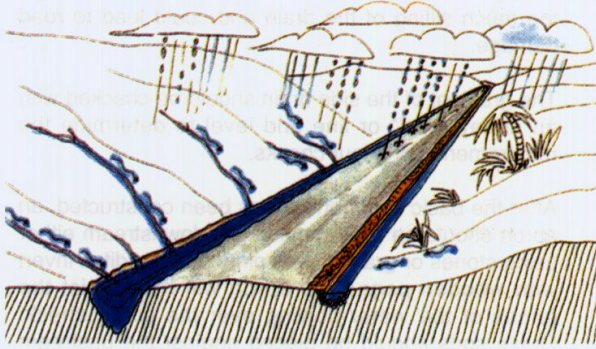
Scour checks should not be constructed on ditches with gradients of less than 4%. This will encourage too much silting of the drain and could lead to road damage.

The gradient of the side drain should be checked with an abney level* or line and level to determine the requirements for scour checks.

After the basic scour check has been constructed, an apron should be built immediately downstream either using stones or grass turves pinned to the ditch invert with wooden pegs. The apron will help resist the forces of the water flowing over the scour check. Grass sods should be placed against the upstream face of the scour check, to prevent water seeping through the scour check and to encourage the silting behind the scour check. The long term objective is to establish complete grass cover over the silted scour checks to stabilise them.

- more substantial **Erosion Control** measures are described on Pages I - 245 to I - 247,
- turfing, wattling and stone pitching of slopes are described on Pages I - 123 to I - 129 and are options for protecting areas downstream from outfalls.

* See List of Terms, Volume I.



PART D - DRAINAGE

Ditches and Drains

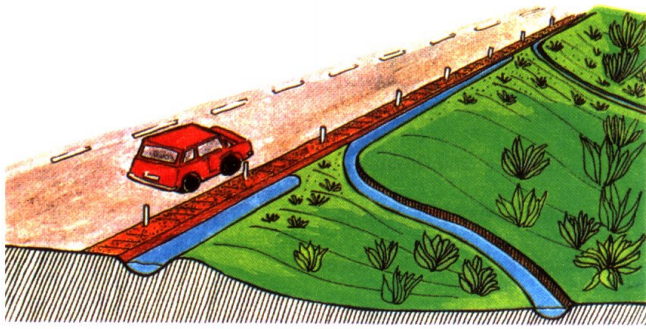
A number of Periodic* activities may be required to achieve more substantial or permanent repairs and improvements to Ditches* and Drains

PROVIDE NEW MITRE DRAIN* (TURNOUT)

EROSION CONTROL:

- a) (Re)Line Drain,
- b) Construct Cascade*,
- c) Construct Flow Spreader*.

**See List of Terms, Volume I.*



Ditches and Drains

PROVIDE NEW MITRE* (TURNOUT) DRAIN

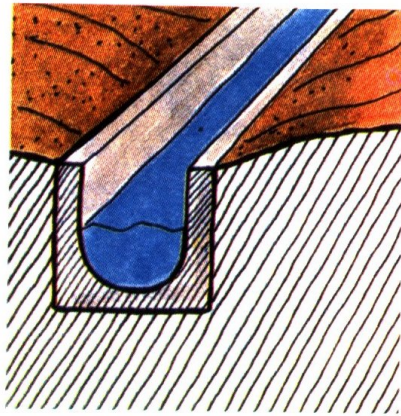
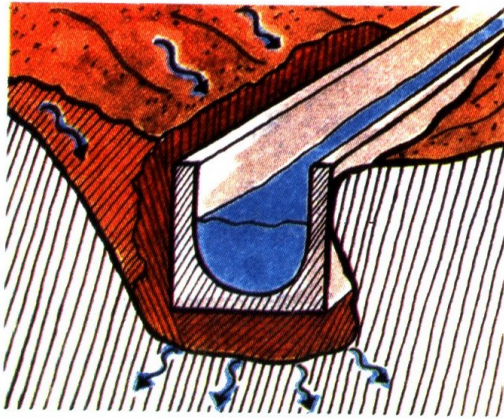
Where water ponds, or the side drain carries too much water or where erosion occurs, it may be possible to construct additional mitre drains (turnouts).

Frequent mitre drains prevent water volumes from building up, and discharge water onto the surrounding land in small quantities, therefore reducing the risk of erosion.

Mitre drains may be desirable at spacings of 20 metres on some gradients. If water cannot be discharged from a drain over a distance of 200 metres, consideration should be given to other options:

- line drain (Page I - 245),
- construct new cross culvert (Page I - 265), to relieve the water flow in the ditch/drain.

**See List of Terms, Volume I*



PART D - DRAINAGE

Ditches and Drains

EROSION CONTROL

a) (Re)Line Drain*

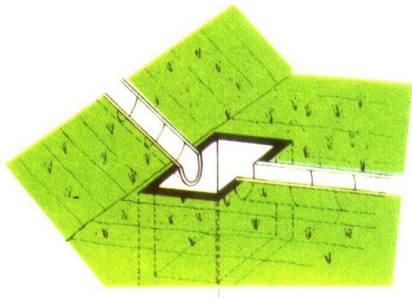
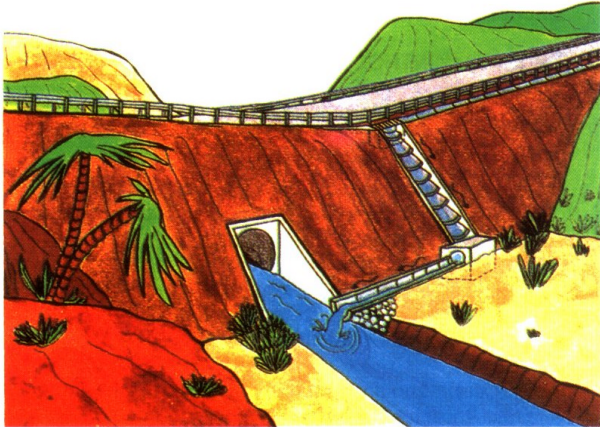
When an unlined drain is frequently damaged, a new lining can be provided. The lining may be constructed with masonry stone, brick, precast concrete tiles or completely precast drain units.

The activity may also be required if an existing lining is substantially damaged by previous poor workmanship, settlement or erosion.

The drain should be hand excavated to the larger cross section required, using the guidelines on Pages I - 223 to I - 225.

After compaction of the earth profile with hand rammers, the stone or concrete panels should be bedded and jointed with mortar of 1 cement : 4 sand.

**See List at Terms, Volume I*



PART D - DRAINAGE

b) Construct Cascade/Catchpit*

Where large volumes of water are required to be taken down a slope, an unlined or lined ditch* will probably provide insufficient resistance to erosion.

A cascade* should be constructed in place of the slope drain* or chute*. Alternatively a basin* or catchpit should be constructed at the base of a lined slope drain or chute.

The cascade or basin will slow the flow of the water and trap silt to reduce the risk of erosion downstream.

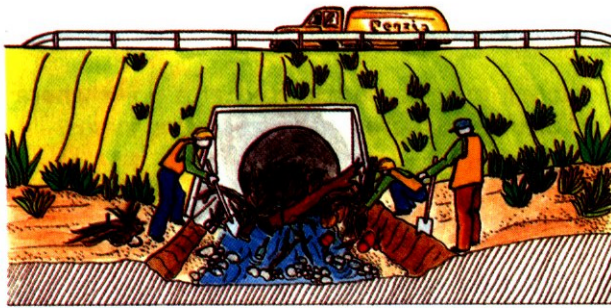
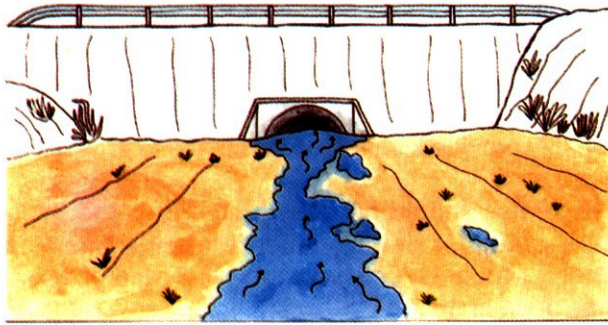
The cascade may be constructed of stone masonry, brick or concrete.

A catchpit may be constructed at a point where a drain changes direction, to resist erosion forces.

c) Construct Flow Spreader*

Where a ditch must discharge onto a steep or fragile slope, the water flow may be dispersed by constructing a flow spreader. This will reduce the risk of erosion. The flow spreader may be constructed of stone masonry, brick or concrete.

**See List of Terms, Volume I.*



CULVERTS*

Routine* Activities

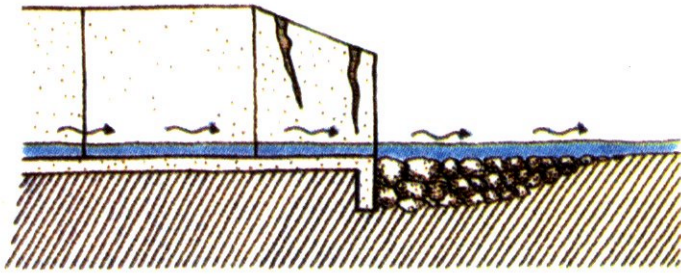
CLEARING AND CLEANING

In order to function properly, a culvert must retain the full opening over its complete length. In addition, the upstream approaches and the downstream area must be free of obstructions. Floating debris (tree branches, bushes, etc.) carried by water is a great danger to culverts. The debris may completely block the culvert inlet.

The following **Routine** activities may be required:

- if debris racks* are already provided, these should be freed of all accumulated obstructions,
- sanding or silting of culverts, especially those with openings smaller than 1 metre, is a particular problem. These culverts can be cleaned by pulling a cable or rope through, to which is attached any suitable object (e.g. a bucket). Alternatively a long handled trowel and spike can be used. If the silting problem continues despite regular clearing, it may be necessary to reconstruct the culvert at a higher level or enlarge it (Page I - 265),
- material and debris from the culvert must be spread or dumped where they cannot cause an obstruction to water flow, preferably on the downstream side of the culvert, well away from the watercourse.

**See List of Terms, Volume I*



Culverts

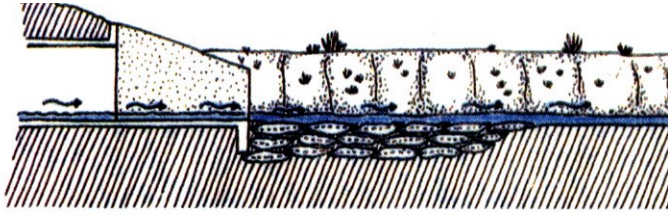
EROSION REPAIR

Major repairs are described under **periodic*** Activities (Pages I-259to1-269).

Where only light erosion of the stream bed has taken place at the culvert* outlet proceed as follows:

- fill eroded area with stone blocks of about 30 cm size to produce a rough energy dissipator. The block pitching or riprap* should preferably extend beyond the eroded area. If larger stone sizes are available, these should also be used. In the dry season or when the water flow is light or non existent, the blocks can be grouted with a concrete mix (1 cement : 4 sand : 8 gravel).
- where stone is not available, logs can be used, lined across the stream bed and extending into the stream banks for anchorage. For additional stability use steel cramps to tie logs to one another.

**See List of Terms, Volume I.*



PART D - DRAINAGE

- jute (or plastic) sacks, filled with soil can also be used as an alternative to rock lining. The soil can be mixed with about 5% cement for extra stability,
- do not overfill sacks. Tie sacks either with soft galvanised wire or strong string so that they cannot open, even when roughly handled,
- lay sacks flat in layers, the sacks in one layer covering the joints in the layer below.



PART D - DRAINAGE

Culverts

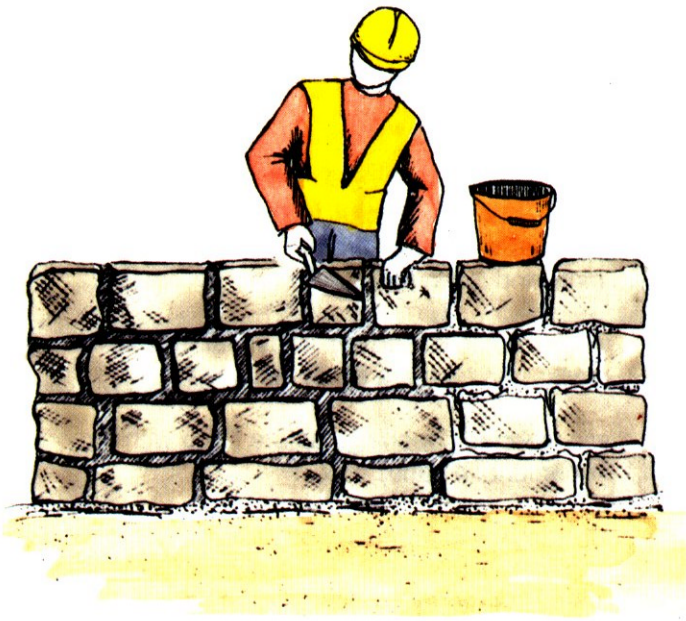
CRACKING REPAIR

Cracks¹ in concrete or masonry are easily identified during low-water or dry periods. They should be repaired as soon as possible.

Proceed as follows:

- clean out all cracks with brush and water. Remove old mortar from any damaged masonry joints and clean the joints,
- where compressed air is available, deposits in cracks can be more easily removed,
- wet the crack openings before filling with a mortar (1 cement : 4 sand),
- fill cracks with mortar,
- trowel the mortar smooth after the crack has been filled.

¹ cracks in dry concrete structure surfaces may be more easily seen, if the surface is first dampened with water using a hand water sprayer or similar.



PART D - DRAINAGE

Culverts

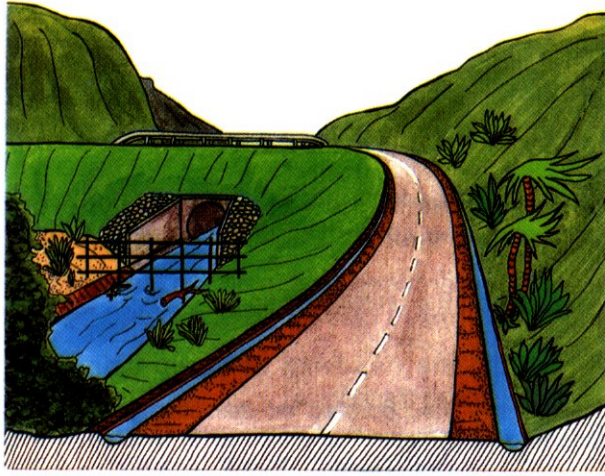
HEADWALL/APRON REPAIR

Where part or all of a masonry or brick headwall/apron* has been damaged by erosion or settlement, a repair should be carried out as soon as possible.

The procedure is:

- remove settled or damaged section of the headwall/apron,
- compact the underlying soil,
- rebuild the headwall or apron using similar materials to the original,
- grout up all joints with mortar (1 cement : 4 sand),
- when the walls are strong enough (after 2 or 3 days) backfill behind walls with soil,
- remove all debris.

**See List of Terms, Volume I.*



PART D - DRAINAGE

Culverts

A number of **periodic*** activities may be required to achieve more substantial or permanent repairs and improvements to Culverts*:

REPAIR OF INVERT*

RECONSTRUCT CULVERT AT CORRECT LEVEL
AND FALL

CONSTRUCT OUTFALL BASIN*

**See List of Terms, Volume I.*



PART D - DRAINAGE

Culverts

REPAIR OF INVERT

Corrugated steel culverts* will corrode if the protective galvanising or coating is damaged. The Inverts* are particularly at risk from this type of damage.

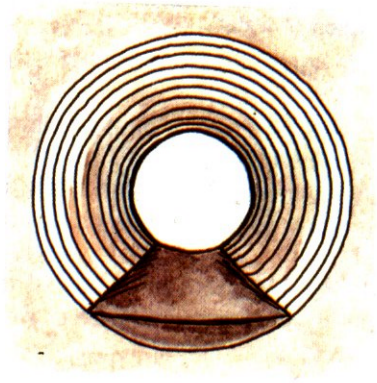
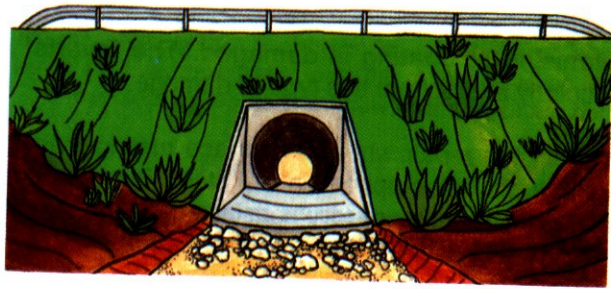
Carry out the repair when the surface rusting starts. Do not wait until holes appear in the steel. Start work after the invert has dried out (dry season work) and all debris has been removed.

METHOD A: Painting with bitumen

- remove any rust from steel sections as far as possible, using steel wire brush, or other suitable tool,
- heat straight run (penetration) bitumen in a suitable bitumen heater until pourable but preferably not heated to more than 100 C,
- apply a thick coat (3 - 4 mm) of bitumen over the lower half of the culvert. The bitumen can be poured and brushed well into the surface. Try to achieve as smooth a surface as possible,
- excess bitumen should not be left on the invert which might allow accumulation of water.

Care must be taken when heating and handling the bitumen, protective gloves and clothing should be worn.

**See List of Terms, Volume I*

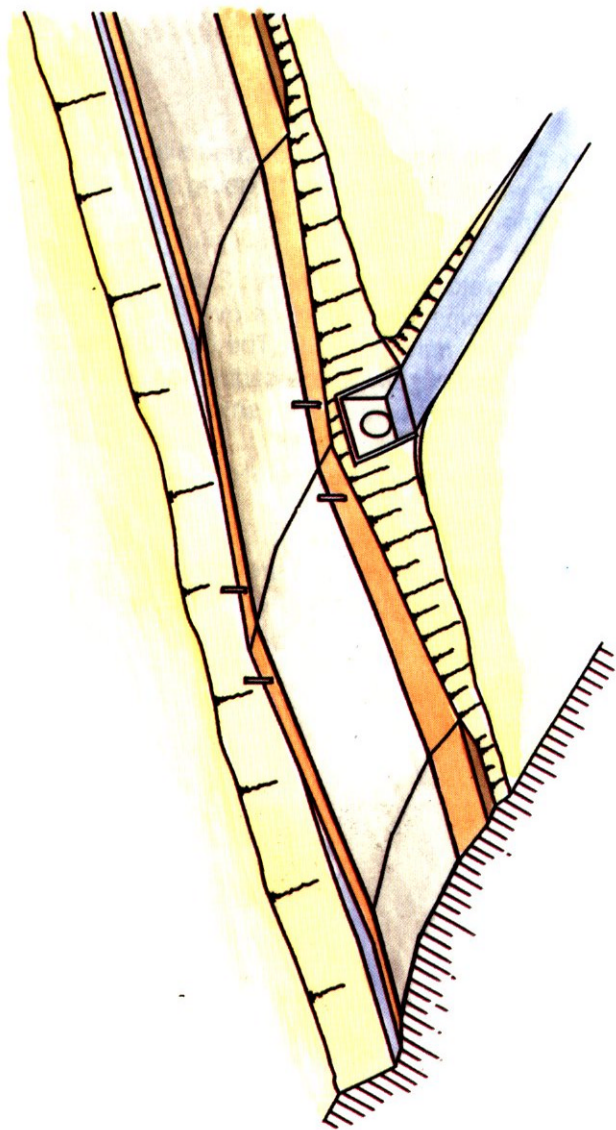


PART D – DRAINAGE

METHOD B: CONCRETE LINING

- remove any rust as previously,
- mark out the edges of the concrete slab along the inside walls of the culvert* using stringline or chalk line,
- pour concrete slab (1 cement : 2 sand : 4 gravel) of 10 cm minimum thickness over the complete length of the culvert invert*. The concrete surface should slope slightly to the centre line axis of the culvert and then be trowelled smooth,
- normally no steel bar reinforcement will be required,
- the inlet and outlet aprons are to be concreted as necessary to adjust for the new culvert invert levels.

**See List of Terms Volume I*



Culverts

(RE)CONSTRUCT CULVERT* AT CORRECT LEVEL AND FALL

Many culverts are installed too low because the horizontal alignment of the road was given priority at design/construction stage.

Where culverts are installed too low they, usually have very long outfalls which repeatedly silt up along with the culverts themselves. Besides requiring a high level of desilting and manpower input, the heaps of desilted material can take up valuable farming land and continue to increase in size. In these circumstances it is advisable to raise the level of the culvert by re-excavation and relaying.

Furthermore culverts of inadequate diameter have sometimes been installed. Culverts of less than 60 cm opening are extremely difficult to desilt, and the preferred minimum size for ease of maintenance is 1 metre.

In these situations consideration should be given to reconstructing the culvert at the correct level and grade, to a suitable diameter (60 cm or larger).

**See List of Terms, Volume I*



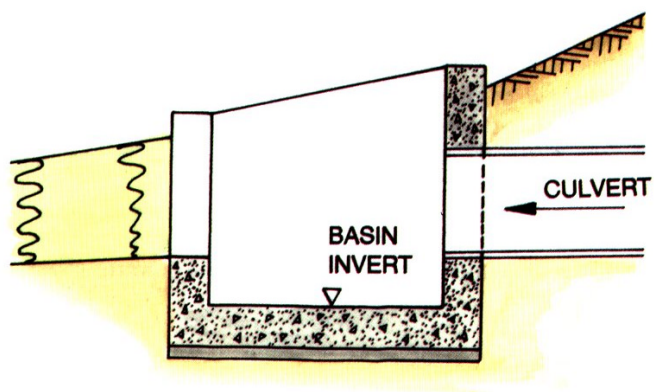
PART D - DRAINAGE

Culverts that have collapsed or are beyond repair should also be reconstructed. Where erosion problems exist in the side drains this may be due to excessive water volume flowing. Consideration should be given to constructing a new cross culvert to relieve the flow in the side drain.

All new or reconstructed culverts should be built according to Road Department designs and specifications.

The road level may need to be raised for a suitable distance either side of the new/reconstructed culvert to accommodate the raised soffit* of the culvert.

**See List of Terms, Volume I.*



PART D - DRAINAGE

Culverts

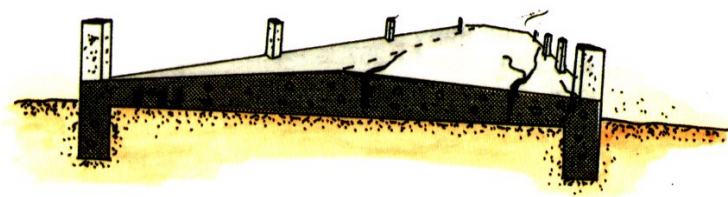
CONSTRUCT OUTFALL BASIN

If a more substantial or permanent repair than described on Page I - 257 is required, a Basin* or Catchpit* structure should be constructed at the outfall of the culvert.

The basin will reduce the energy in the water and allow it to flow downstream with less risk of erosion.

The basin may be constructed of stone, brick or concrete.

**See List of Terms, Volume I*



Drifts* and Causeways*

Routine* Activities

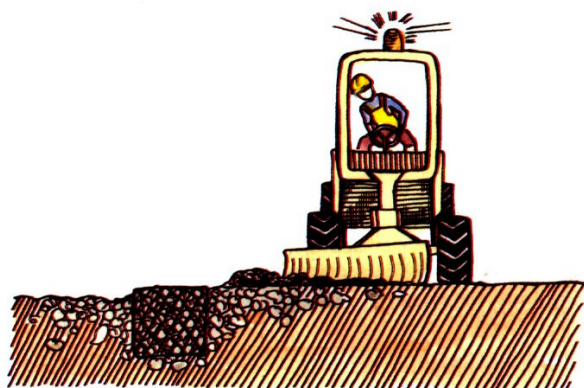
MINOR REPAIRS

In the case of paved fords (masonry, brick or concrete slab), cracks should be filled with a bituminous mortar. Before filling, remove all soil and sand and clean thoroughly with water. Refer to Volume III "Maintenance of Paved Roads", Crack Sealing (Page III - 57).

Potholes should be broken out down to slab depth, cleaned and then filled with concrete (1 cement : 2 sand 4 gravel), mortared stone work or bricks as appropriate.

Erosion cavities immediately upstream or downstream of the drift or causeway should be filled with large stones or rip rap. In the case of serious or recurring erosion, ~ mattresses should be laid on the bed of the watercourse with their top surface at the same level as, or slightly below the level of, the drift or causeway inverts*.

**See List of Terms, Volume I*



Drifts* and Causeways*

GRADING/CLEARING

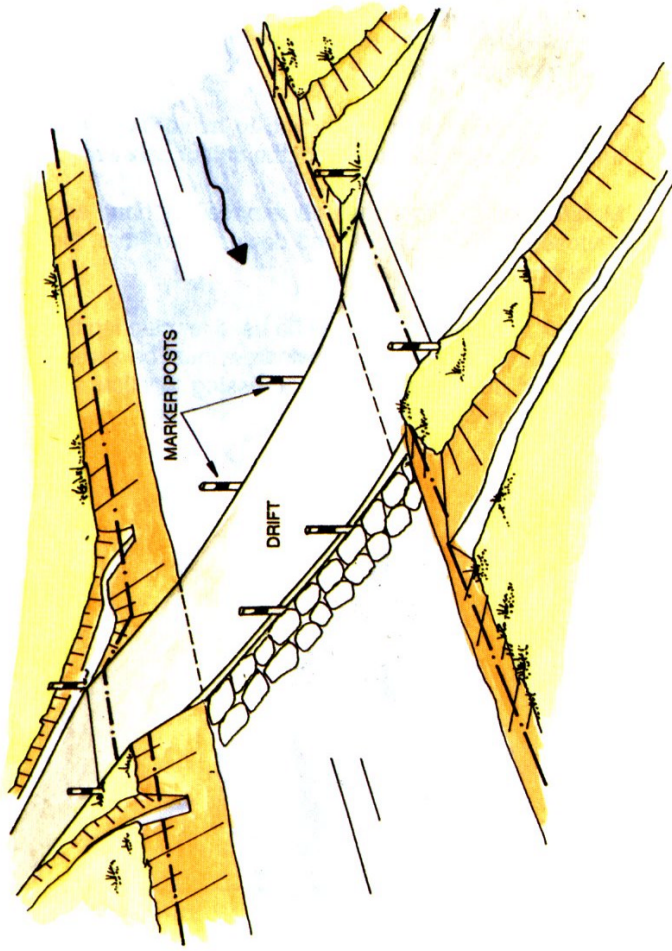
Water will deposit silt, sand and debris on the drift* or causeway* from time to time, and in or against the causeway openings.

This must be regularly removed to avoid danger to traffic and the risk of erosion at the drift or causeway.

Material and debris should be removed by hand and disposed of well clear of, and downstream from, the crossing.

A motor or towed grader may be used for clearing the paved surface, however the windrow must be spread clear and downstream of the crossing to allow the free passage of water.

**See List of Terms, Volume I*



PART D - DRAINAGE

REPLACE GUIDE-POSTS

Missing or damaged marker or guide-posts on drifts or causeways should be replaced as required before the flood season. Use steel pipe of suitable diameter and length and painted in black and white sections.

- examine the pipe sockets, remove water, sand, silt, loose mortar etc. if present. Socket depth should be at least 15 cm. Use mason's hammers and chisels to enlarge or deepen the hole if necessary,
- place the pipe in the socket and pack it if necessary to the correct position and height. Use a mortar (1 cement : 3 sand) to grout the space between pipe and socket wall,
- timber guide-posts are not recommended as they can easily break. However hardwood posts can be used if properly anchored in the socket (tight fit) so that they will not be washed away with the following flood.



PART D - DRAINAGE

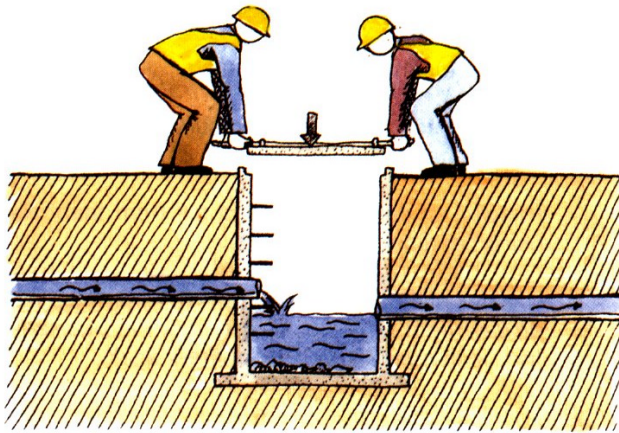
Manholes* and Drainage Pipes'

Routine* Activities

CLEAR MANHOLE AND UNDERGROUND PIPES

- remove manhole cover or grating,
- before entering manhole, ensure it is free from noxious gases,
- remove all debris, sand and silt from manhole using handtools and buckets,
- if water still cannot flow, rod from the manhole downstream of the blockage until the blockage has been removed and water flows again,
- if rodding from the downstream manhole is not successful or not possible, pump water from the water-filled manhole and attempt to clear the blockage from this manhole using rodding equipment.

**See List of Terms, Volume I.*



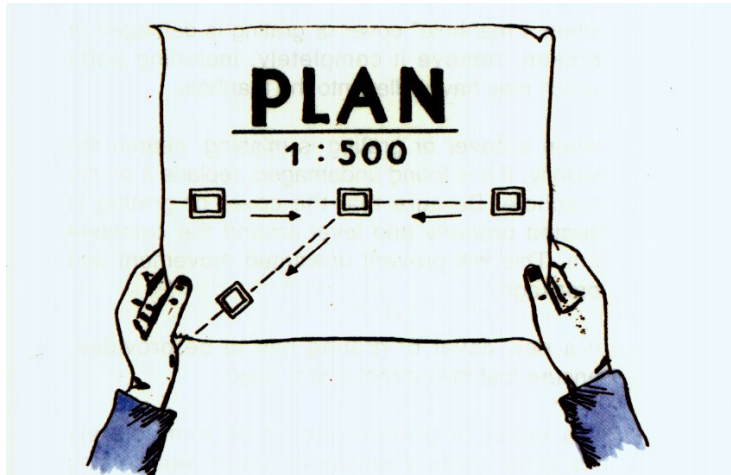
PART D - DRAINAGE

Manholes* and Drainage pipes*

REPLACE MANHOLE COVER OR GRATING

- when a manhole* cover or grating is damaged or broken, remove it completely, including parts which may have fallen into the manhole,
- when a cover or grating is missing, search the vicinity. If it is found undamaged, replace it on the manhole. Be sure that the cover or grating is seated properly and level around the complete rim. This will prevent unwanted movement and breakage,
- if a new cover or grating has to be provided, ensure that the correct size is used,
- if a cover or grating cannot be immediately replaced, make a temporary cover repair using wooden planks of adequate thickness.

**See List of Terms, Volume I.*



PART D - DRAINAGE

Manholes* and Drainage Pipes*

CLEAR MANHOLE AREA

- locate manhole* using the drainage plan, or by trial excavations,
- remove all vegetation within a distance of 2 to 3 metres from the manhole and remove from the site,
- excavate all deposits of silt or soil covering the manhole down to a depth of at least 10 cm below manhole cover level and for a distance of at least 1 metre from the manhole edges,
- check that the manhole is free of sand or silt and replace the cover.

CLEAN CATCH PIT SUMP

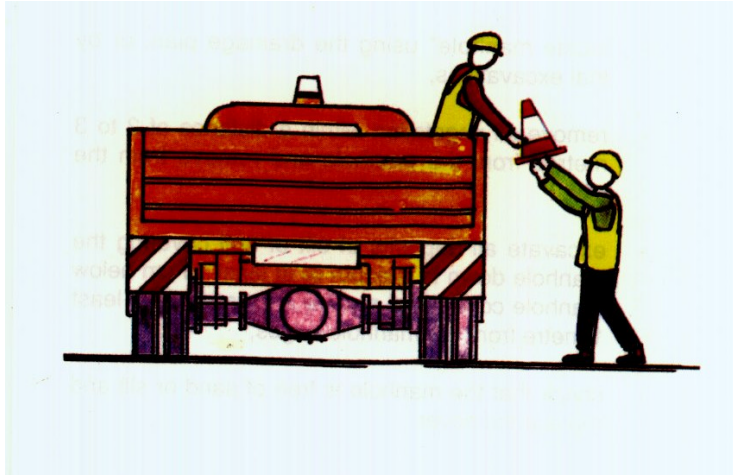
Follow the same procedure as for CLEAR MANHOLE AND UNDERGROUND PIPES (described on Page I - 277). Remove all silt and debris from the catchpit sump.

Periodic* Activities

RELAY DRAINAGE PIPE

Reconstruct pipe to correct levels and grade, and to construction specifications.

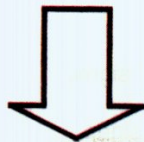
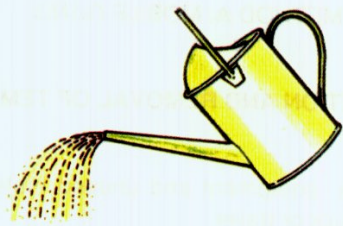
**See List of Terms, Volume I.*



METHOD A: MOBILE GANG

4.4 COMPLETION AND REMOVAL OF TEMPORARY SIGNS

- Load tools, equipment and unused materials back onto the truck or trailer.
- Where they have been used remove the signs, cones and barriers and load them onto the truck or trailer in the following order:
 - 1 "End of Restriction" signs,
 - 2 Traffic cones,
 - 3 "Speed Limit" signs,
 - 4 Barriers,
 - 5 "Road Narrows" signs,
 - 6 "Men Working" signs.



PART D - DRAINAGE

- Ensure that the site is left clean and tidy with no stockpiles of material left behind.
- Move onto the next job.
- Inspect traffic signs and clean if necessary.

TYPICAL WORK REPORT

ROADSIDE AREAS

Work Report No: Date:

District: Gang

Zone Road No

Section: from km to km

Location(s):

WORK ACHIEVED:

MANPOWER USED:

Name	Grade	Hours worked
Name	Grade	Hours worked
Name	Grade	Hours worked

EQUIPMENT USED: DIESEL USED:

Hrs	litres
Hrs	litres

MATERIALS USED:

COMMENTS:

Foreman:

4.5 WORK REPORT

The report must be filled in **each day**, detailing:

- the work carried out,
- the resources used.



PART D - DRAINAGE

METHOD B: LABOUR BASED

In some road maintenance Systems an individual attendant or lengthman lives close to a road and is responsible for the ROUTINE MAINTENANCE activities on that road.

The following activities are suitable for this method:

Ditches and Drains

CLEARING AND CLEANING
RESHAPE/REGRADE/DEEPEN
EROSION CONTROL
PROVIDE NEW MITRE (TURNOUT) DRAIN

Culvert

CLEARING AND CLEANING EROSION REPAIR

Drifts and Causeways

GRADING/CLEARING

Manholes and Drainage Pipes

CLEAR MANHOLE AND UNDERGROUND PIPES
CLEAR MANHOLE AREA
CLEAN CATCH PIT SUMP



PART D - DRAINAGE

METHOD B: LABOUR BASED

5. RESOURCES

5.1 PERSONNEL

■ Supervisor

- 1 foreman or overseer visiting regularly.

■ Workforce

- attendant or lengthman.



PART D - DRAINAGE

METHOD B: LABOUR BASED

5.2 PLANT AND TOOLS¹

- 1 broom,
- 1 pickaxe,
- 1 shovel,
- 1 hoe or mattock,
- 1 rake,
- 1 hand rammer with metal shoe,
- 1 wheelbarrow,
- 1 bucket or watering can,
- 1 grass slasher, sickle or scythe,
- 1 bush knife or bush hook,
- 1 axe,
- 1 bowsaw,
- 1 file for sharpening tools,
- 1 long handled shovel/spike for culvert cleaning,
- 1 ditch template and spirit level.

¹ Depending on activities to be carried out.



5.3 MATERIALS

The activities suitable for attendant or lengthman do not require imported materials. For simple ditch checks (timber and stones), materials can usually be obtained in the area of the work.

5.4 SIGNS AND SAFETY EQUIPMENT

No special arrangements are required for **Traffic Signs or Clothing.**



PART D - DRAINAGE

METHOD B: LABOUR BASED

6. MAINTENANCE METHOD

6.1 PRELIMINARY TASKS

- The handtools are assigned to the attendant who keeps them at his home for use as necessary.
- The worksheet will indicate the location and extent of the work to be carried out and the time required for the job.



METHOD B: LABOUR BASED

6.2 EXECUTION OF THE WORK

- The attendant should use the wheelbarrow to carry the tools and safety items to the site, and collect any materials locally.

- The work report must be filled in for each day's work.

Notes and Sketches

User of this Handbook:

NAME:

ADDRESS:

DATE:

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GENERAL INDEX

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The contents of this handbook draw on many sources, past and present, and it would be impossible to acknowledge them all individually. Much of the material is an updating of the UN/ECA Maintenance Handbook for Africa, compiled by experts from France, Germany and the United Kingdom, and published in 1982. Its three volumes encapsulated the broad experience of highway engineers, maintenance managers, consultants and researchers from many different countries.

The present revision was undertaken by Mr R.C. Petts of Intech Associates, in close association with the Overseas Centre of the Transport Research Laboratory. The work was funded by the UK Overseas Development Administration and supported and guided by a subcommittee drawn from the PIARC Committee on Technology Transfer and Development (C3). It benefited from the collective wisdom of that committee and the countries represented within it. These included Australia, Algeria, Belgium, Brazil, Burkino Faso, France, Germany, India, Italy, Morocco, Poland, Portugal, Senegal, Spain, Turkey, the United States of America, the United Kingdom and the World Bank.

On behalf of the subcommittee I would like to record our sincere thanks to all those who contributed, in whatever way, to the production of this second version of the Maintenance Handbook and to making it more valuable to a wider international audience. I am sure it will fulfil its intended purpose of strengthening the capabilities of maintenance workforces and giving them a stronger sense of professional pride in the vital work they are doing.

ACKNOWLEDGEMENTS continued

Any revision of this kind is an ongoing process, and comments or suggestions for further improvements should be made known to the PIARC Central Office at 27 rue Guenegaud 75006 PARIS, France.
Fax +33(1) 46 3384 60

J Stuart Yerrell
Chairman, Subcommittee C3-6d

WHAT IS PIARC?

Founded in 1909 following the 1st International Road Congress held in Paris in 1908, the Permanent International Association of Road Congresses (PIARC) is the oldest of the international associations concerned with roads and road engineering.

The general aim of the Association is to improve international co-operation and to foster progress in:

- the formulation of road transport policies
- the planning, construction, improvement and maintenance of roads
- the operation and management of road systems

within the context of wider policies towards transport.

To achieve these aims PIARC:

- organises a World Road Congress every four years and various technically oriented events
- creates and co-ordinates Committees
- publishes a number of documents including a periodic bulletin

It is assisted in its task by National Committees. PIARC is a non political and non-profit association

It was granted consultative status, category II, to the Economic and Social Council of the United Nations in 1970.

The official languages of PIAC are French and English

There are several categories of members: Governments, regional authorities, public bodies, collective members and Individual members

As of 1 January 1994, PIARC has 72 member Governments and 2100 members in 100 countries.

PIARC has strong links with several regional organisations and is in favour of networking between countries dealing with similar questions. PIARC may help to create and/or develop such networks.

PIARC Committees and Working Groups are composed of engineers and experts appointed by member countries. They act on a continuous basis between each Congress and participate in international meetings dealing with subjects within their competence

On average they hold two plenary meetings a year. As of 1 January 1994, Committees and Working Groups gather approximately 700 engineers and experts from 40 countries.

Thirteen Committees and four Working Groups are active (period 1991 - 1995)

- **COMMITTEES**

- C 1 Technical Committee on Surface Characteristics
- C 3 Committee on Technological Exchanges and Development
- C 4 Committee on interurban Roads
- C 5 Committee on Road Tunnels
- C 6 Committee on Road Management
- C 7 Technical Committee on Concrete Roads
- C 8 Technical Committee on Flexible Roads
- C 9 Economic and Finance Committee
- C 10 Comm 11cc on Urban Areas
- C 11 Committee on Road Bridges
- C 12 Technical Committee on Earthworks Drainage, Subgrade
- C 13 Committee on Road Safety
- C 14 Committee on the Environment

- **WORKING GROUPS**

- G 1 PIARC Winter Road Congress
- G 2 Natural Disaster Reduction
- G 3 Modern Traffic Control and Management
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