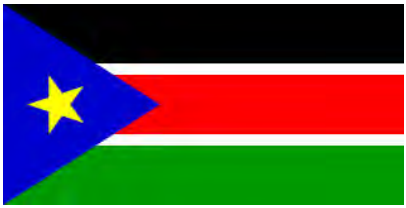
LOW VOLUME ROAD MAINTENANCE BOOKLET

South Sudan

Ministry of Roads & Bridges (MRB)

Government of South Sudan

May 2013



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FOREWORD

This first edition of the Low Volume Road Maintenance Booklet has been prepared after circulation and discussion of a draft with the aim of gathering comments and contributions from stakeholders and potential users.

It is intended that the document will be further refined from time to time to gather further local experience and facilitate application for maintenance of Low Volume Roads throughout South Sudan.

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This Booklet forms part of the South Sudan Low Volume Roads Manual.

ACKNOWLEDGEMENTS

Some material for this Booklet has been taken from the World Road Association (PIARC) International Road Maintenance Handbook. Additional images have been provided by Intech Asset Management and UNOPS. Material has been adapted from the ERA LVR Manual and Road Maintenance Booklet, and other regional experience and documentation. This SS LVR Booklet has been prepared under coordination by UNOPS with support provided by UKAID through AFCAP.

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1. THE AIMS OF THIS BOOKLET

This Booklet has been developed by the Government of South Sudan as one of a number of initiatives to help rapidly expand, develop and maintain the Low Volume Road network to provide greatly improved road access and lower the costs of transport for rural communities.

The Booklet is applicable to earth, gravel and paved roads that may be carrying up to about 300 motor vehicles per day.

The Booklet specifically sets out guidance for road and other authorities and agencies, contractors, local communities, and private road owners on how to maintain road access making the best use of the limited resources available to them. It also advises how it may be possible to mobilise outside resources to enhance the impact of their own initiatives.

By focussing on the use and mobilisation of available local resources, such as a range of materials and local labour and skills, it is entirely possible to build and maintain durable all-weather road access suitable for all traffic from pedestrians and animal transport up to buses and trucks, and at reasonable cost.

The Booklet advises:

- What is Maintenance?
- What needs to be done to achieve all-year Basic Road Access,
- How to identify the main problems/defects and solve them,
- How to make the most of local materials and skills,
- How to maintain the road access at low cost,
- How to make priorities
- How to organise and plan the work
- Where to obtain further advice and outside assistance.

The Maintenance activities and codes used in this Booklet are provisional, pending development of National Road Maintenance Specifications.

2. SOME BASIC QUESTIONS

What is a road?

A road is a vital asset for economic and social development, constructed with a running surface to allow the passage of motor or other vehicles. It is defined as having a camber (crossfall) to shed rainwater to the side, and a system of side drains and other drainage features to discharge water away from the running surface. A track, by comparison, may have neither of these features. A road may be earth surface, gravel or paved.

What is a Low Volume Road?

A Low Volume Road (LVR) is generally one that generally carries less than 300 motor vehicles of traffic each day (total vehicle flow both ways).

What is Maintenance?

Maintenance is the range of activities necessary to keep a road and associated structures in an acceptable condition for road users, as intended when it was design and constructed.

What is the Essence of Road Maintenance?

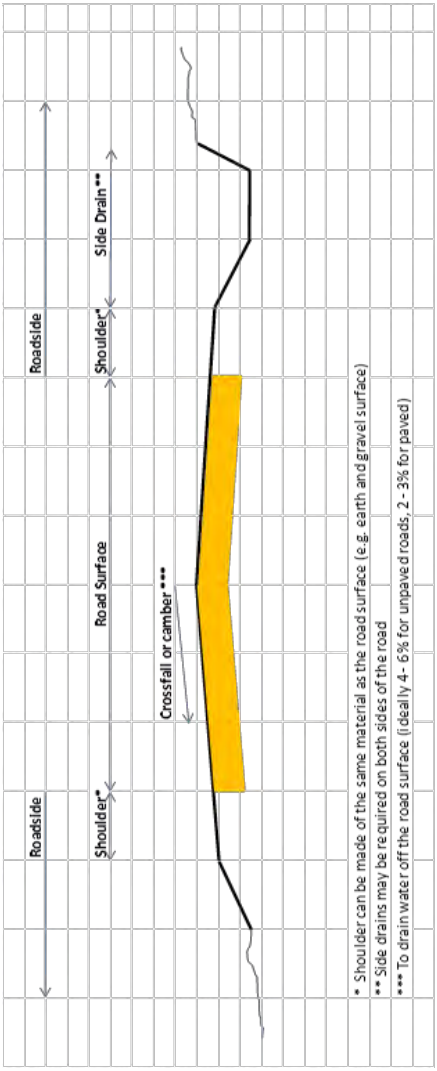
For Low Volume Roads, maintenance can be summarised in three basic aims:

- **Keep the road surface in good condition (for example, repair ruts and potholes),**
- **Maintain the road surface camber to shed water to the side of the road,**
- **Maintain the drainage system to safely lead water away from the road.**

All maintenance activities are organised to carry out or support these basic aims.

3. ROAD FEATURES

Road Cross Section (imagine a vertical slice through the road)

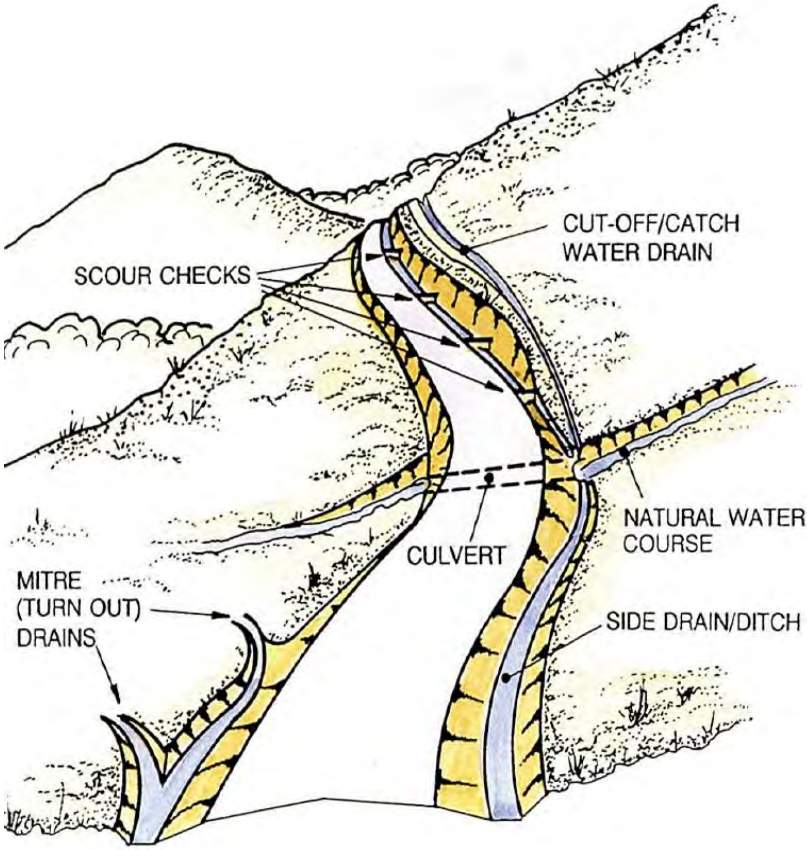


* Shoulder can be made of the same material as the road surface (e.g. earth and gravel surface)

** Side drains may be required on both sides of the road

*** To drain water off the road surface (ideally 4 - 6 % for unpaved roads, 2 - 3% for paved)

Drainage Features



Structures (bridges, drifts or culverts) are usually provided at watercourse crossing points.

The Terminology Section (15) provides the explanation for each road term or feature.

4. BASIC ACCESS

Basic Access is achieved to provide year-round passage to routes by turning them from weather-dependent tracks into proper roads. A proper road can be formed from the natural soil (Engineered Earth Road) in many locations.

The main features of a road are:-

- A camber to shed rainwater to each side of the road
- Side drains, turnout drains, drifts and culverts (or other structures) to manage the water collected from the road surface and to discharge it carefully to avoid erosion or other problems.

This usually means that the road surface needs to be slightly higher than the ground at the road side.

Drainage of an earth road to ensure year-round access must be achieved by 2 key features: -

1 maintaining cross fall (camber) to drain rain water off the road,

and

2 ensuring that rain water flows from the edge of the road surface (the shoulder) into side drains, or down the embankment slopes, and away from the road.

If these features do not exist now, then they should be provided as soon as possible.

Most natural soils can be built into an (Engineered Natural Surface - ENS) Earth Road. However, for route sections with weak soils, or if traffic increases to more than about 50 motor vehicles per day, or on steep hills, it may be necessary to improve the road surface with gravel or various types of paving. This can be achieved at relatively low cost by applying **a Spot Improvement** approach to improve these limited problem sections, often using local labour and materials. Other Parts of the LVR Manual describe how such improvements can be designed and constructed.

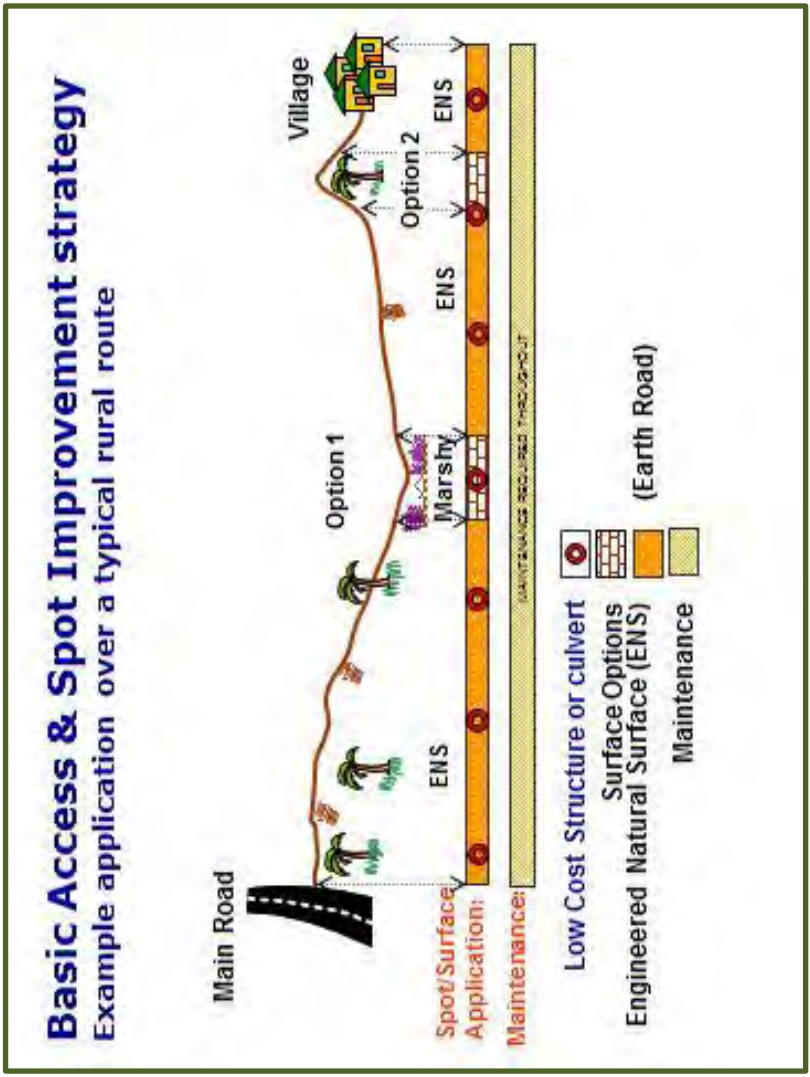
Most routes can be built to Engineered Natural Surface (ENS) – Earth road standard for most of their length. If in doubt about soil suitability, seek advice from the MRB or State Road Authority. The **Spot Improvements** at problem sections of the route may be selected from the following list of options and surface improvements:

- Drift or other structure
- Culvert
- Embankment
- S-01: Engineered Natural Surface (ENS)
- S-02: Natural gravel
- S-03: Waterbound/Drybound Macadam
- S-04: Hand Packed Stone
- S-05: Stone Setts or Pavé
- S-06: Mortared Stone
- S-07: Dressed stone/cobble stone
- S-08: Fired Clay Brick, Unmortared/mortared joints
- S-09: Bituminous Sand Seal
- S-10: Bituminous Slurry Seal
- S-11: Bituminous Chip Seal
- S-12: Bituminous Cape Seal
- S-13: Bituminous Otta Seal
- S-14: Non-reinforced concrete
- S-15: Wheel track paving

The choice of spot improvement should be based on the location features and the materials and skills available locally. Great care should be used in using gravel as a road surface in some circumstances. It is unlikely that it will be suitable due to high costs of replacing the surface material that will be lost due to rainfall or traffic, or dust nuisance in the locations; where:

- Traffic is more than 200 motor vehicles per day
- Annual Rainfall is greater than 2,000mm
- Slope of road surface is more than 6%
- Through community settlements
- The haul distance from the quarry/pit to the road site is more than 10km
- The road section experiences flooding, or
- The gravel is of poor quality.

Despite initial low construction costs, it is important to appreciate that under a **Basic Access and Spot Improvement** strategy it is essential to arrange the necessary **Regular** maintenance of the ENS and any gravel surface and drainage, and **Occasional** maintenance of the improved surface sections and structures, to preserve the initial construction investment.



5. FULL ACCESS

Where sufficient funds or resources are available, a Low Volume Road may be constructed to **Full Access** standard. This should provide uninterrupted all-year, high quality, relatively high speed, low surface roughness access. There should be no closures in the rainy season.

In practical terms **Full Access** may involve the provision of a gravel or sealed/paved surface throughout the length of the route link.

This level of access will also require appropriate levels of regular maintenance. The annual cost and resources required for this maintenance may be more than for **Basic Access**.

6. THE PURPOSE OF MAINTENANCE

From the moment that a road is constructed or upgraded, it will deteriorate due to the effects of weather and traffic. Maintenance is required to be carried out from time to time to restore its condition to be close to its as-constructed state. If maintenance is not carried out the road will continue to deteriorate making passage increasingly difficult, uncomfortable and expensive to road users. The road may even become impassable for part or all of the year.

It is convenient to view **Maintenance** as correcting **Defects.**

In practical terms it is useful to identify and quantify the **Defects**, and then arrange the necessary **Maintenance** to be carried out. In this Booklet **Defects** and **Maintenance** activities are grouped into the following colour coded groups:

Regular Maintenance (Routine)

Roadside Activities

Drainage

Road Surface
- Earth Road
- Gravel Road

Structures

Occasional Maintenance (Periodic)

Road Surface
- Gravel Road
- Paved Road

Structures

This Booklet covers the treatment of some 30 common **Defects**. From time to time, other defects/activities may be required. Advice should be obtained from the MRB or State road authorities for any problem or road aspect not covered in this Booklet.

7. REGULAR MAINTENANCE

These are the maintenance activities that are likely to be required somewhere on a road link every year. Most of the tasks may be carried out manually. Mechanised or equipment based alternatives are available for some tasks as indicated.

Regular Maintenance is conveniently divided into four main groups of activities that are often carried out on a seasonal basis:

Roadside Activities

Drainage

Road Surface

- Earth Road
- Gravel Road

Structures

Roadside Activities

Defect	Maintenance Activity (Page No.)
1. Trees and bushes growing on roadside	131 Brush clearing (P21)
2. Shoulder uneven or eroded, or does not drain properly	132 Shoulder Rehabilitation (manual) (P25)
3. Shoulder erosion	133 Plant grass and water (P28)
1. Grass on shoulder or in drain requires cutting	134 Cut grass (P21)
2. Shoulder uneven or eroded, or does not drain properly (minor)	240 Shoulder Blading (mechanised) (P25)
2. Shoulder uneven or eroded, or does not drain properly (major)	241 Shoulder Rehabilitation (mechanised) (P25)

Drainage

Defect	Maintenance Activity (Page No.)
4. Culvert silted/obstructed	121 Culvert Cleaning (P31)
5. Ditch silted	122 Ditch Clearing (Manual) (P34)

6. Ditch or slope eroded (minor)	123 Repair Erosion Damage (Selected Fill) (P42)
7. Ditch or slope eroded (major)	124 Repair Erosion Damage (rockfill) (P44)
7. Slope eroded (major)	129 Wattling (P44)
8. Mortared Masonry damaged	125 Mortared Masonry Repair (P48)
9. Dry Masonry damaged	126 Dry Masonry Repair (P51)
10. Gabion structure damaged	127 Gabion Structure Repair (P53)
11. Erosion in ditch	128 Build wooden/stone scour check (P56)
5. Ditch silted	230 Ditch clearing (mechanised) (P34)

Road Surface

Defects and maintenance requirements depend on the road surface type.

Earth Road

Defect	Maintenance Activity (Page No.)
12. Road surface potholed, rutted or uneven, and does not drain to edge	112 Reshape & Compact Earth Road Camber (P59)

Gravel Road

Defect	Maintenance Activity (Page No.)
13. Road Surface potholed	110 Spot Repair Selected Material (P68)
13. Road Surface potholed	111 Spot Repair Crushed Aggregate (P68)
14. Road Surface rutted or uneven, and does not drain to edge (Minor: <3cm))	220 Blade Gravel Road (light) (P73)

15. Road Surface rutted or uneven, and does not drain to edge (Major: >3cm)	221 Blade Gravel Road (heavy) (P80)

Structures (Bridges/Drifts/Large Culverts)

Some of these activities will require skilled personnel

Defect	**Maintenance Activity (Page No.)**
16. Debris or vegetation affecting or endangering structure	400 Cleaning, Clearing, Sweeping, De-silting, Unblocking or Removal of vegetation or flood/wind borne debris (Structure/ inlets/outlets) (P90)
17. Connectors/fixings are loose/damaged/missing	401 Repair of loose/missing connectors/fixings (P92)
18. Planks/kerbs are damaged/missing	402 Replace damaged or missing planks or kerbs (P93)
19. Paintwork defective or damaged	403 Paint main or minor parts of structure/furniture (P94)
20. Danger or evidence of insect or moisture attack of timber components	404 Apply wood preservative or insect treatment to timber components (P96)
21. Masonry or concrete or joints defective (minor)	405 Pointing or repair of masonry/concrete (P97)
22. Structure furniture defective	406 Repair parapets, marker posts, safety barriers, signs or other furniture (P98)

8. OCCASIONAL MAINTENANCE

These are the maintenance activities that may be required somewhere on a gravel or paved road section or link, or on a structure, after a period of a number of years. The category of repair depends on the type of road surface constructed. Some of the Occasional Maintenance tasks may be carried out manually with the aid of simple tools or equipment. Others will require skilled personnel or large equipment. Transport may be required for the haulage of materials. Many of the activities will require careful planning and mobilisation of the necessary resources.

Gravel or Paved Road

Defect	Maintenance Activity (Page No.)
23. Gravel layer too thin	317 Gravel Resurfacing (Selected Material) (P99) 318 Gravel Resurfacing (Crushed Aggregate) (P99)
24. Paved road pothole or surface defect	113a Spot /pothole Repair (Macadam) (P106)…….. 113b Spot /pothole Repair (Stone setts) 113c Spot /pothole Repair (Mortared stone) 113d Spot /pothole Repair(Dressed stone) 113e Spot /pothole Repair(Emulsion chip seal) 113f Spot /pothole Repair(Emulsion sand seal) 113g Spot /pothole Repair(Emulsion gravel/slurry seal) 113h Spot /pothole Repair(Un-mortared brick) 113i Spot /pothole Repair(Mortar jointed brick) 113j Spot /pothole Repair(Non- reinforced concrete) 217 Pothole Reinstatement (cold mix) 219 Pothole (Base Failure Repair)

Structures (Bridges/Drifts/Large Culverts)

Defect	Maintenance Activity (Page No.)
25. Random stone filling defective	410 Repair Random Stone filling (P116)
26. Retaining wall defective	411 Retaining wall repairs (P117)
27. River or stream bed scoured adjacent to structure	412 Watercourse scour repairs (P118)
28. Gabion walls or mattress defective	413 Gabion basket repairs (P120)
29. Structural repairs for the following serious defects: Structural timber decay, splitting or insect attack, bulging masonry, cracked concrete or masonry, honeycombed concrete, spalling concrete, serious rust or chemical stains, exposed or corroding reinforcement or pre-stressing steel, damp patches on concrete, seriously corroded structural steelwork, damaged/distorted structural steelwork, missing/loose rivets, bolts or other fixings, cracks in structural steelwork, settlement of deck, piers, abutments or wingwalls, expansion joint or bearing defects, erosion requiring piling works.	414 Major structural repairs. These will require the expertise of an Engineer to assess and design/specify the remedial works in response to the scale and nature of the defects (P122)

9. ROAD MAINTENANCE TOOLS

Road Maintenance activities require a range of simple and inexpensive tools and control aids. However construction quality tools are preferable to agricultural quality. For further guidance see Reference 5.

10. MAINTENANCE ACTIVITIES

REGULAR MAINTENANCE (ROUTINE)

ROADSIDE ACTIVITIES

Defect 1: Grass, weeds, bushes or trees have been allowed to grow unchecked at the side of the road.

Development, if neglected:

- drainage ditches cannot be cleaned
- surface water can pond at the edge of the road and weaken the road surface,
- silt can accumulate at the edge of the road,
- the visibility for road users is reduced, with increased risk of accidents with persons or animals,
- increased fire hazard in the dry season.

Maintenance Activity

- **134 Grass Cutting**
- **131 Bush Clearing**

These two activities may be required individually or together. With the exception of arid areas, these are Regular activities, involving control of grass, weeds, bush and trees where these are not controlled by animal grazing. They may be required to be carried out at least once a year after the rainy season, or more often where the climate causes vegetation to grow rapidly.

- Grass Cutting

Grass and weeds should be cut at least once a year after vegetation reaches full growth or according to local experience. The vegetation should be trimmed by hand. Sickles, scythes, slashers, bushknives, or similar handtools will be required.

- Bush control & Trees

Any bushes on the road shoulders or drains should be cut down. Dead or leaning trees within the right-of-way which may fall on the roadway 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 one- or 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.

- Disposal of debris

All cuttings and debris should be disposed of safely so that there is no risk of drains being blocked or fire hazard.

- 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:

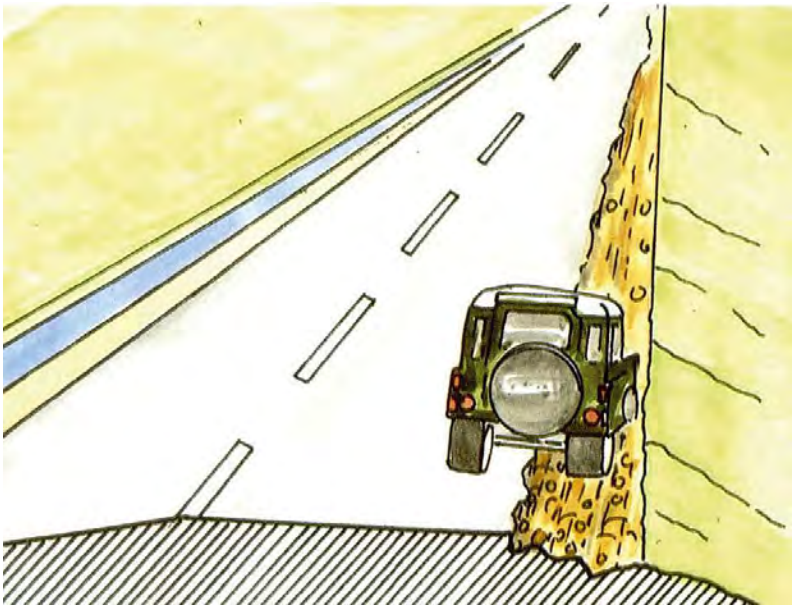
  - herbicides can cause pollution of crops, rivers and streams and drinking water supplies,
  - herbicides are often dangerous to health,
  - herbicides are expensive, and must often be imported,
  - herbicides do not always produce satisfactory results.

- Burning

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

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

Defect 2: Shoulder eroded, mis-shaped or does not drain away from roadway



Development, if neglected:

- hazard to road users, increased risk of accidents,
- obstruction of water flow from roadway,
- inadequate support for the road surface,
- water collects and softens/weakens the shoulder and pavement
- the edge of the pavement will break when vehicle wheels run over it,
- the roadside ditch may become blocked by the excess material.

Maintenance Activity

- **132 Shoulder Rehabilitation (manual)**
- **241 Shoulder Rehabilitation (mechanised)**
- **240 Shoulder Blading (mechanised)**

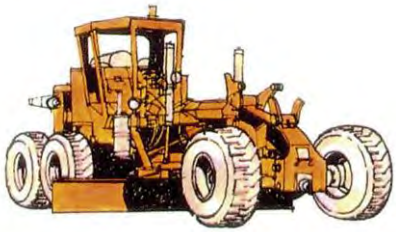
a) Rehabilitation Manual Method (132)

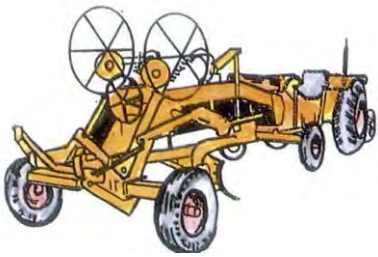
The low surfaces and all high material should be loosened with a pick axe or mattock. The shoulder should be reshaped to slightly above the final level and the correct crossfall using a shovel and rake. Any low spots should be topped up with fresh material of the same type and quality as the existing shoulder. 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 roadway or in the drainage ditch. If the shoulder 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 roadway. Check the finished crossfall with the camber board and repeat the reshaping if necessary. Brush all loose material and debris from the roadway.

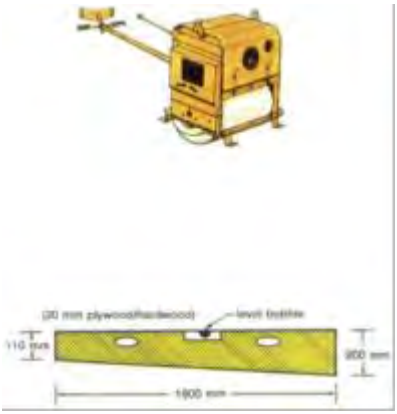
b) Rehabilitation Mechanised Method (241)

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 a number of passes of the motor or towed grader blade. Care must be taken not to damage the edge of the roadway with the blade. Any low spots should be topped up with fresh material of the same type as the existing shoulder. 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 roadway or into the drainage ditch.

If the shoulder 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 roadway. Check the finished crossfall with the camber board and repeat the reshaping if necessary. Brush all loose material and debris from the roadway.







c) Shoulder Blading (mechanised) (240)

This Regular maintenance activity may be carried out if no additional material is required to be added to the shoulder. The shoulder material should contain sufficient moisture to enable the reshaped material to be compacted by the grading equipment or a roller. It is therefore ideally carried out in the rain season. Otherwise, water should be added to ensure a more durable surface finish.

Defect 3: Existing roadside surface requires protection from erosion (this activity may be required as a follow up from Maintenance Activity 123)

Development, if neglected:

On some steep slopes or erodible soils surface scour may occur if vegetation cover is not established. This could damage to the roadway, shoulders, drainage system or earthworks.

Maintenance Activity

- **133 Plant grass and water**

a) 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/additive 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.

b) Turfing (grass sodding)

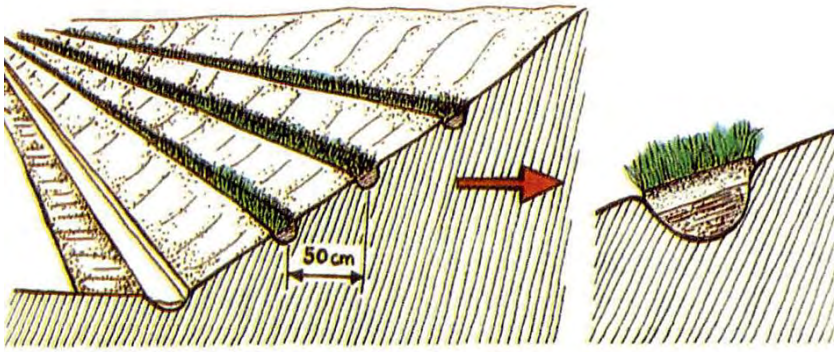
This method is suitable when climate and soil conditions are favourable and when fresh grass sods (soil clumps containing grass and its roots) are available.

The general procedure is:

- prepare the area to be turfed 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.

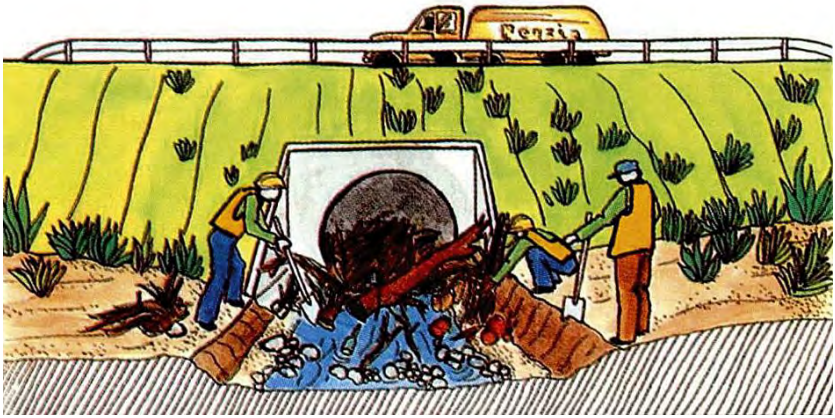
Other patterns of sodding are:

- 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.


50cm

DRAINAGE

Defect 4: Culvert silted or obstructed with debris



Development, if neglected:

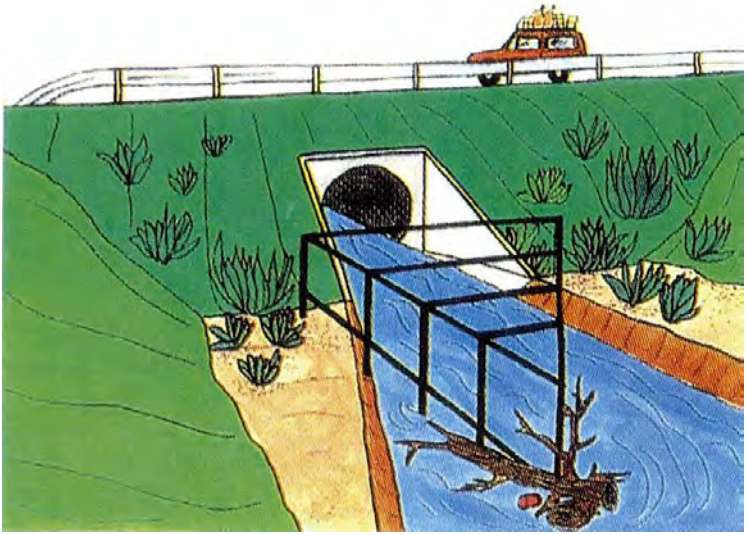
The intended waterway opening will be so reduced that flood water cannot flow as intended. Flood water will back-up or pond on the upstream side of the culvert and may eventually over-flow the road embankment. The road is then in danger of being washed away.

Maintenance Activity

- **121 Culvert 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 Regular Maintenance activities may be required:

– if debris racks are already provided, these as well as the culvert opening should be freed of all accumulated obstructions,



– Clear any sand, silt or debris from inside the culvert. Sanding or silting of culverts, especially those with openings smaller than 1 metre, can be 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.

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.

This Maintenance task is best carried out before the rains and after any heavy rainstorm.

Defect 5: Ditch silted

Ditch partially or fully blocked by vegetation growth, bushes, fallen trees, debris, loose silt, loose rocks.

Development, if neglected:

Concentration of flood flow causing erosion and possible overtopping and damage to roadway, paving or shoulders.

Maintenance Activity

- **122 Ditch Clearing (Manual)**
- **230 Ditch clearing (Mechanised)**

a) Manual Method (122)

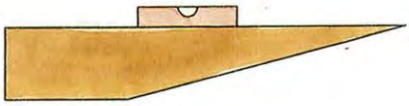
This is a **Regular Maintenance** activity. The object is to remove all soil, high vegetation, materials and objects from the ditch which could possibly interfere with water flow or cause an eventual blockage of the ditch. This can include for example, rocks, loose silt and sand, weeds, trees, bushes, 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 ditch. NO soil material or debris should be placed on the

roadway. On unlined ditches a short grass cover can help to stabilise the bottom and sides of the ditch. Therefore where a side ditch 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 drain surface together.

At some locations it may be necessary to RESHAPE/REGRADE/DEEPEN the ditch.

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 & slope template should be used to obtain the correct drain shape.



DITCH AND SLOPE TEMPLATE

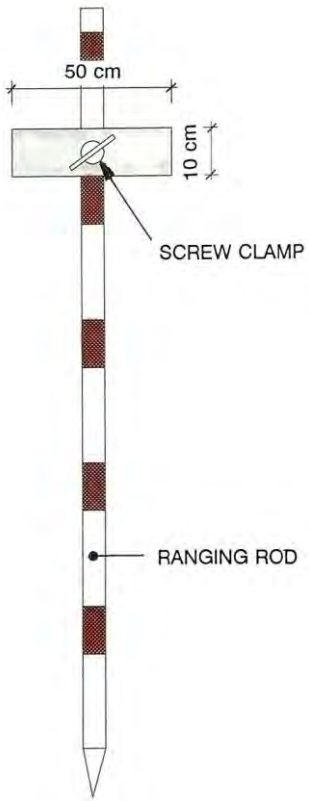
- using the template a 50 cm wide slot should be excavated to the correct ditch shape every 10 metres along the drain. The slots act as a guide for excavating the ditch to the correct shape,
- in flat areas, the gradient of the ditch should be checked using ranging rods and profiles or similar methods, 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.

- 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 ditch & slope template (SLOPES).

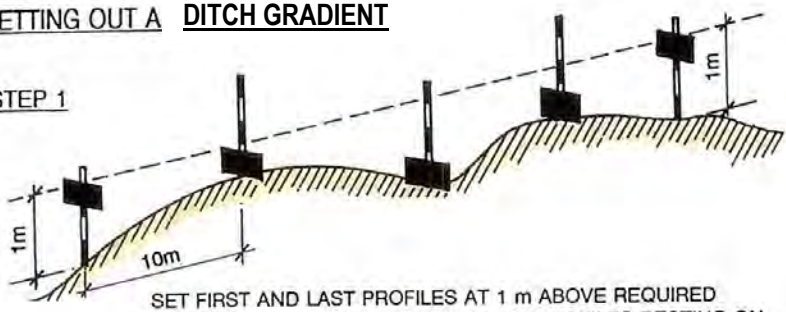


The alignment or route of the drain should be set out using stringlines and pegs. The ranging rods and profiles should be set up at the start and outfall of the ditch. Intermediate profiles may be required on long ditches. The levels of intermediate slots can be determined using the traveller.

This Maintenance task is best carried out before the rains and after any heavy rainstorm.

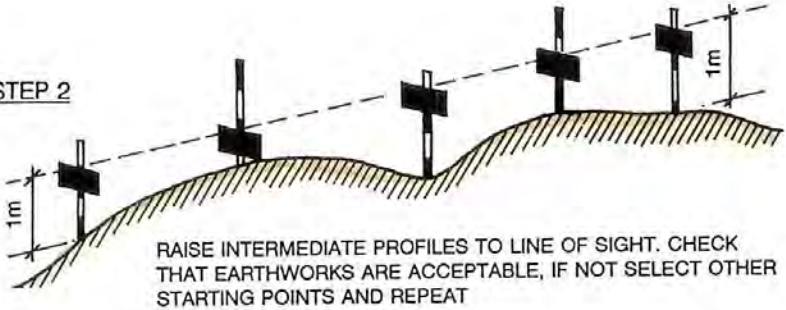
SETTING OUT A **DITCH GRADIENT**

STEP 1



SET FIRST AND LAST PROFILES AT 1 m ABOVE REQUIRED FINISHED DITCH LEVEL, INTERMEDIATE PROFILES RESTING ON GROUND

STEP 2

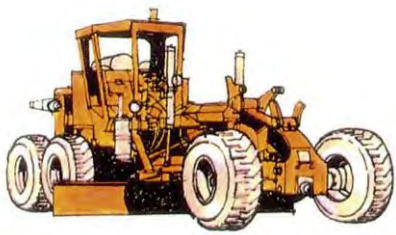


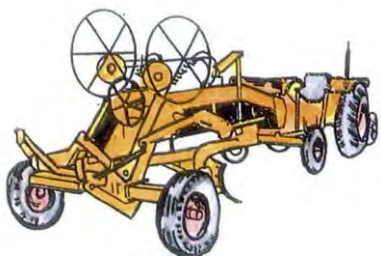
RAISE INTERMEDIATE PROFILES TO LINE OF SIGHT. CHECK THAT EARTHWORKS ARE ACCEPTABLE, IF NOT SELECT OTHER STARTING POINTS AND REPEAT

STEP 3

PLACE NEW DITCH LINE PEGS AT EACH RANGING ROD WITH TOPS AT 1 m BELOW THE PROFILE BOARDS - THIS IS THE FINISHED DITCH CENTRE LINE LEVEL .

b) Mechanised Method (230)





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 by cutting in the direction of water flow in the ditch.

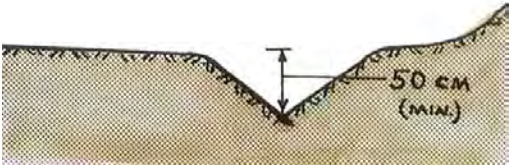
Case 1:

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, using the blade to windrow the soil to the bottom of the ditch between the rear wheels. (This can be repeated to obtain the desired depth of ditch. This part of the task can also be done manually),
- the next blade pass(es) are to clean the invert of the ditch by removing the windrow to the top of the ditch at road shoulder,
- the final pass is required to move the windrow material away from the shoulder ditch edge.

If the recovered material quality is inferior to that of the road surface, THE MATERIAL MUST BE REMOVED FROM THE SITE.

- 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) Manual Method (122).


50 cm
(min.)

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) Manual Method (122).

Defect 6: Ditch or slope eroded (minor)

Development, if neglected:

Damage to drainage system, roadway, structures, paving or shoulders.

Maintenance Activity

- **123 Repair Erosion Damage (Selected Fill)**

This activity may be sufficient for minor erosion damage to a ditch. However, reconstructing the ditch profile with selected fill material alone may not be sufficient to prevent the defect recurring within a short time. Loose stones or boulders should be removed. The defective section of ditch should be cut back to firm material and fresh material placed in layers not exceeding 15cm thickness and compacted with a hand rammer. If the material is dry it should be sprinkled with water before compaction. The added material should be trimmed back to the correct ditch profile and checked with the ditch template. Dispose of the excess materials well away from the roadside so that water flow will not be impeded and they will not fall or wash back into the ditch.

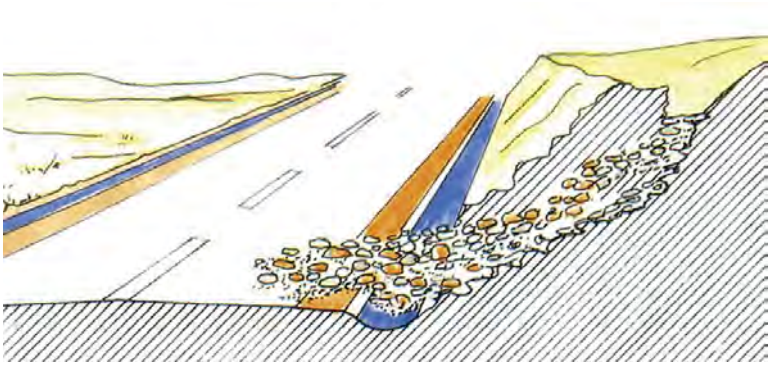
Scour checks may need to be installed to prevent recurrence.

Similar minor repairs may be carried out to eroded slopes.

It is likely that additional measures will be required such as:

- 133 Plant grass and water
- 124 Repair Erosion Damage (rockfill), or
- 128 Build wooden/stone scour check
- 135 Wattling

Defect 7: Ditch or slope eroded (major)



Development, if neglected:

Damage to drainage system, roadway, structures, earthworks paving or shoulders.

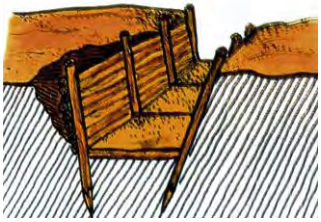
Maintenance Activity

- **124 Repair Erosion Damage (rockfill),** or
- **129 Wattling**

A number of activities are possible to repair erosion damage to ditches and slopes. However it is important to try to determine the cause of the erosion so that the repair will minimize the risk of it recurring. It is advisable to obtain Engineer's advice where erosion is extensive.

Ditches

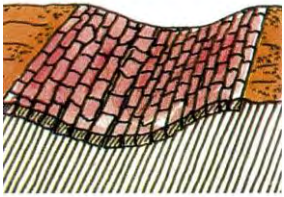
Drain sections are often laid at a steep gradient or on sharp bends without erosion protection along or at the outfall of the drain. The following options should be considered:



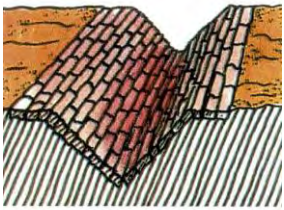
- **Repair the ditch with rockfill lining**
- Repair the ditch with timber lining
- Provide masonry lining

- Regrade/Realign ditch
- Provide relief ditch or culvert

Slopes

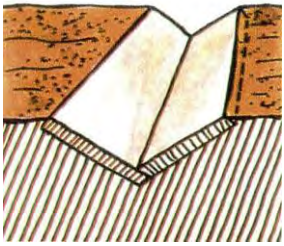


Slips or slope erosion/ instability are usually caused by adverse ground conditions or ground/surface water or both. The remedial works should be specified by an Engineer after an inspection of the site and the necessary investigations. Works are likely to be expensive and it is important to ensure an appropriate solution to the problem.



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

The cheapest solution (if appropriate) is expected to be **Wattling**. Other principal, but more expensive, remedial options are:



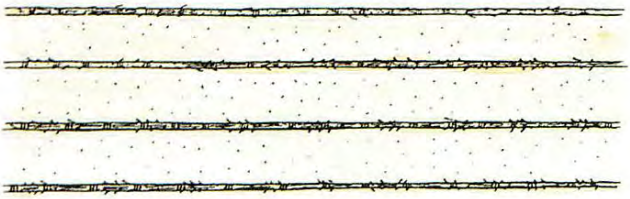
- counterfort drains
- stone pitching the slope
- reducing slope angle,
- clearing slip material,
- surcharging the slope,
- gabions,
- cribwork,
- masonry retaining wall,
- concrete retaining wall.

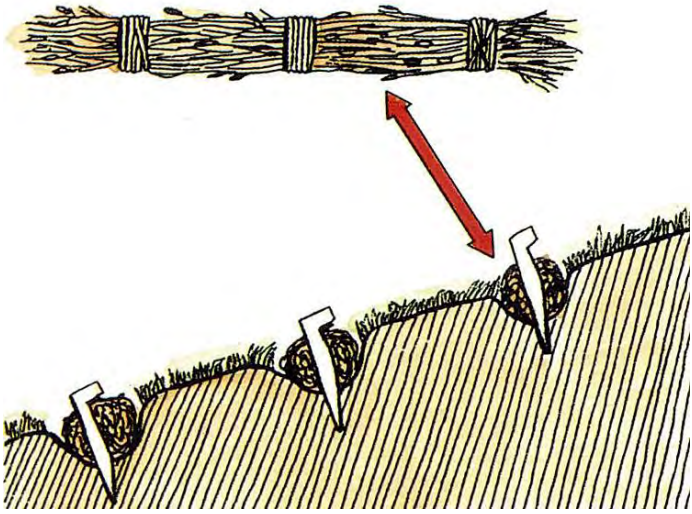
Wattling (129)

This activity may be suitable after repairing an eroded slope with Maintenance Activity: **123 Repair Erosion Damage (Selected Fill)**

Wattling will help to resist surface water erosion of a slope. Wattles 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 out,
- 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.





Defect 8: Mortared Masonry damaged

Development, if neglected:

Further damage to structure or roadway, slope or structural failure.

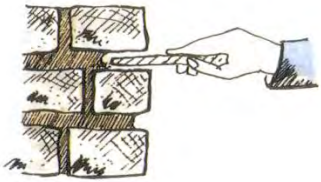
Maintenance Activity

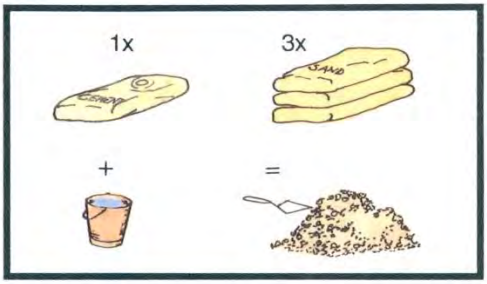
- **125 Mortared Masonry Repair**

This activity should only be carried out on masonry structures in reasonably good condition. If the structure has settled or is in danger of collapse, only complete reconstruction can be recommended.

- clean and rake out defective joints of weak mortar, soil and vegetation using compressed air or a water spray, hammer and chisel,
- at locations where the joint has to be completely renewed, the stone or brick should be eased out of place temporarily until a new mortar bed is placed,
- replace missing stones with sound pieces
- use templates and stringlines if necessary to ensure the correct shape and incline of the face of the mortared masonry work,
- dampen the joint surfaces where fresh mortar has to be applied,
- mix a mortar of cement and sand as required or specified (normally 1 cement: 3 sand) and add only enough water to permit mortar to be well mixed and applied,

- apply fresh mortar to joint, filling all space available, compacting with a suitable wooden rammer. Do not use mortar which has fallen on the ground,
- smooth joints with a suitable tool (a piece of rubber or plastic water hose, or bent reinforcing steel),
- the final mortar surface should be inset slightly from the stone/brick surface to achieve a tidy finish,
- in dry or windy weather conditions, mortar can dry out too quickly. Prevent this by sprinkling water on joints after the mortar has set and until mortar has completely hardened. Alternatively cover the work area with wet jute sacks or similar,
- clean visible stone or brick surfaces which have been stained by mortar or cement-water in the process of the work so that the finished work will present a neat appearance,
- remove surplus materials and leave the site in a clean and tidy condition.




1x
3x
+
=

Defect 9: Dry Masonry damaged

Development, if neglected:

Further damage to structure or roadway, slope or structural failure.

Maintenance Activity

- **126 Dry Masonry Repair**

Try to use the established local dry stone construction techniques.

This activity should only be carried out on dry masonry structures in reasonably good condition. If the structure has settled or is in danger of collapse, only complete reconstruction as a dry masonry or more substantial structure can be recommended.

- carefully take down the defective areas of dry stone masonry, stacking the stone for re-use,
- clean and rake out defective joints of soil and vegetation using hammer and chisel, and brush,
- re-build the dry stone work using the salvaged stones and carefully selecting each stone to ensure good bonding horizontally and through the width of the stonework. Use smaller stones to wedge the larger ones where necessary,
- add new stones if necessary,
- use templates and stringlines if necessary to ensure the correct shape and incline of the face of the dry masonry work,
- pack the spaces between stones with soil or gravel,
- remove surplus materials and leave the site in a clean and tidy condition.

Defect 10: Gabion structure damaged

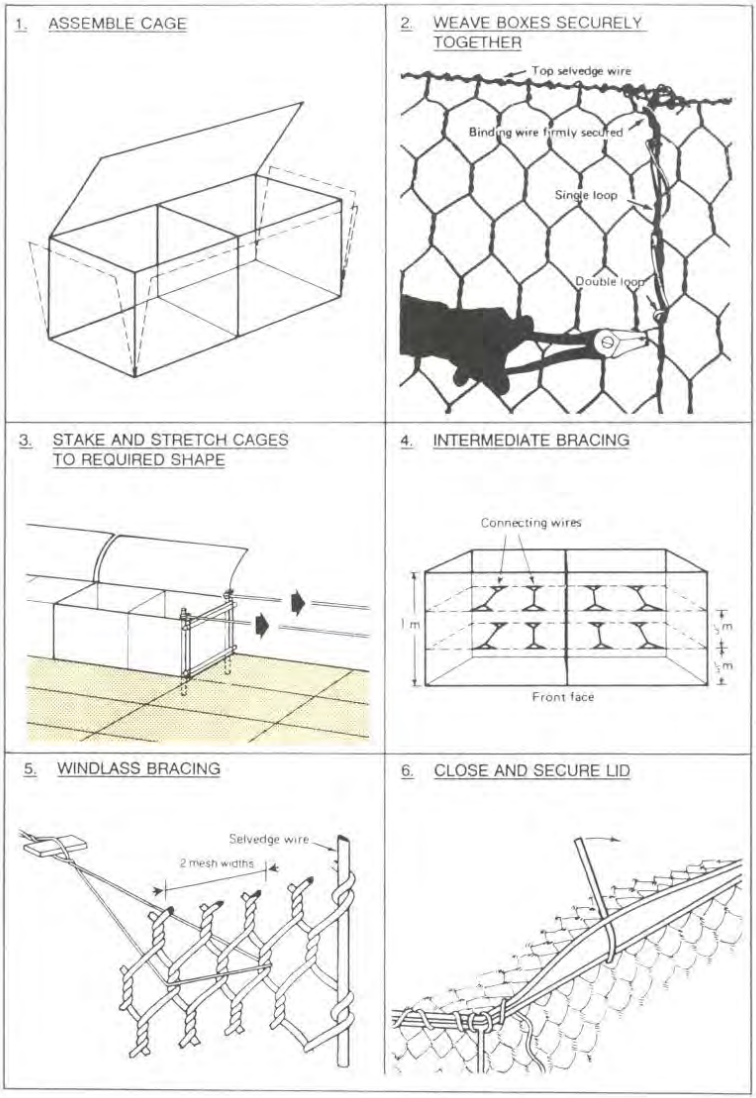
Development, if neglected:

Further damage to structure or roadway, slope or structural failure.

Maintenance Activity

- **127 Gabion Structure Repair**

Gabions are usually made of zinc coated steel baskets, although may also be made from welded mesh sheets, galvanised chain link fencing and woven wire depending on the circumstances and locally available materials. The baskets are hand-filled with rock and stones between 12 and 30 cm size. In this way they attain great stability, but will allow minor settlement. Repairs may be required due to bulging or breaking of the basket due to foundation or backing movement, or settlement of the stone within the basket. Gabions are designed to allow some settlement. Repairs should aim to ensure that the stone continues to be contained. Repairs will normally consist of opening the baskets, re-packing the stone inside, topping up stone if necessary, renewing bracing ties and re-securing the lid of the gabion. It may be necessary to weave new cage material over broken or deformed areas, and any suitable steel mesh or woven sheets can be used for this. Where a gabion box is required to be replaced or added, the procedure for building a new gabion box should be used as follows.



The gabion baskets are normally supplied folded flat complete with tying wire so that the transport volume is minimised. Foundations should be

excavated level and cleaned as for a conventional structure, with any unsuitable material removed and replaced with good soil, stone or gravel, and compacted. The baskets should be erected in their final position. Cages should be woven together using 3 mm binding wire securing all edges every 15 cms with a double loop. The binding wire should be drawn tight with a pair of heavy duty pliers and secured with multiple twists (1 and 2). The centre gabion only should be filled initially to act as an anchorage. The connected baskets should be stretched and staked with wires and pegs to achieve the required shape (3). Filling should be carried out by hand using hard durable stones not larger than 250 mm and not smaller than the size of the mesh. The best size range is 125 to 200 mm. The stones should be tightly packed with a minimum of voids. Boxes of 1 metre height should be filled to 1/3 height. Horizontal bracing wires should then be fitted and tensioned with a windlass to keep the vertical faces even and free of bulges (4 and 5). Further bracing should be fixed after filling to 2/3 height. 500 mm height boxes should be braced at mid height only. 250/330 mm deep gabions do not require internal bracing. The stones should be carefully packed to about 3 to 5 cms above the top of the box walls to allow for settlement. Smaller material can be used to fill the voids on the top face, but excessive use of small stones should be avoided. The lids are then closed and stretched tightly over the stones, (carefully) using crowbars if necessary (6). The corners should be temporarily secured to ensure that the mesh covers the whole area of the box. The lid should then be securely woven to the tops of the walls removing stones if necessary to prevent the lid from being overstretched.

Defect 11: Erosion in ditch

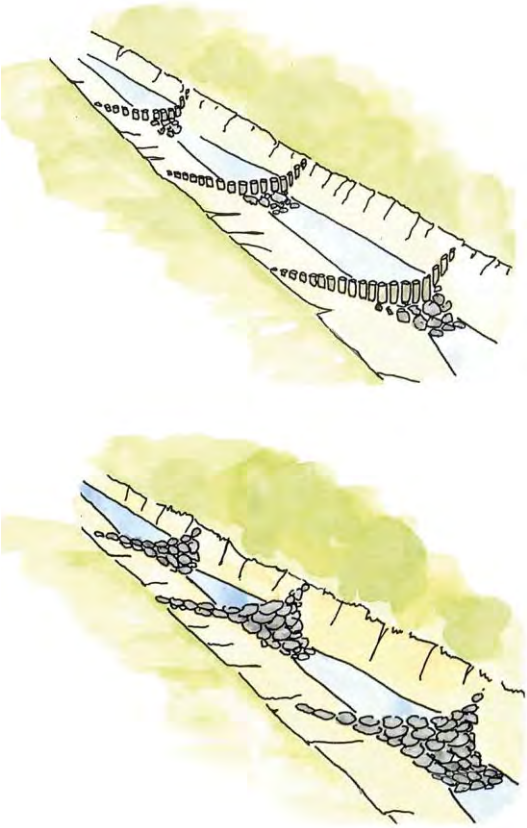
Development, if neglected:

Damage to drainage system, roadway, structures, paving or shoulders.

Maintenance Activity

- **128 Build wooden/stone scour check**

Unlined ditches may suffer from scour of the invert and sides. Simple repairs may be achieved by filling the affected areas with soil and trimming to the correct profile, and turfing where climatic conditions are favorable. 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 roadway. The scour check construction should therefore be controlled with the aid of a template. 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 (spacing guidance in the SS LVR Manual).

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.

Well constructed scour checks will allow the water to gently cascade over (and not through) the checks, removing energy from the water and reducing erosion power.

ROAD SURFACE

Whenever works are carried out on the road surface, warning signs should be placed before each end of the work site.

EARTH ROAD

Defect 12: Road surface potholed, rutted or uneven, and does not drain to edge

Development, if neglected:

Road becomes waterlogged or impassable.

Maintenance Activity

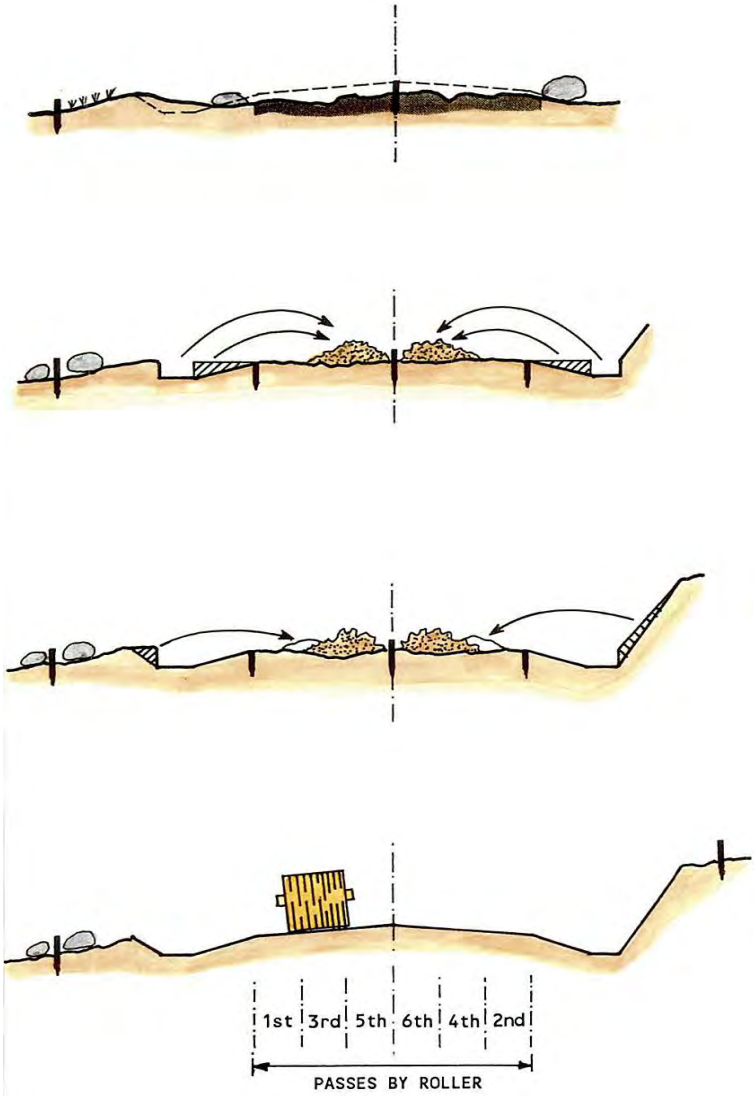
- **112 Reshape & Compact Earth Road Camber**

This activity is carried out using labour, basic hand tools and control aids. The Method comprises the following steps:

- SETTING OUT
- EXCAVATION OF DITCH AND SLOPE
- EXCAVATION OF BACKSLOPE

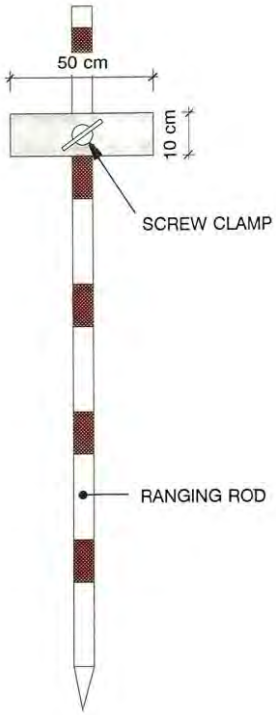
- CAMBER FORMATION AND FINAL COMPACTION

  These steps are shown on this page**.**



SETTING OUT

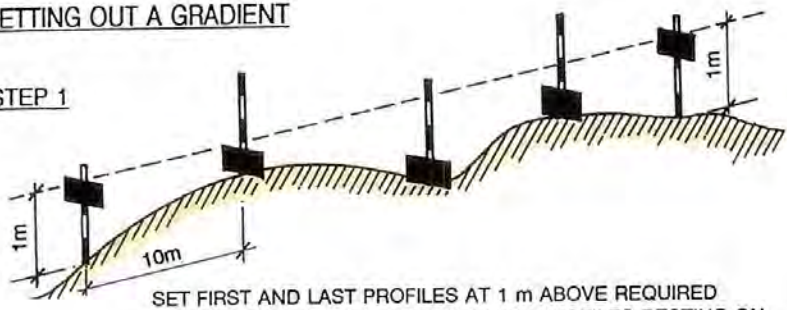
- The PROFILE method of setting out enables a smooth vertical alignment to be re-established on a severely deteriorated road surface.
- The alignment will consist of straight gradients and vertical curves.
- The centre line of the road is pegged every 10 metres.
- A ranging rod is fixed at each 10 metre peg.
- Each ranging rod is fitted with a profile board. The profile board can slide up and down the ranging rod and be clamped at any height.



Setting out is arranged in sections of 60 to 100 metres, which approximate to either a straight gradient or vertical curve on the road line.

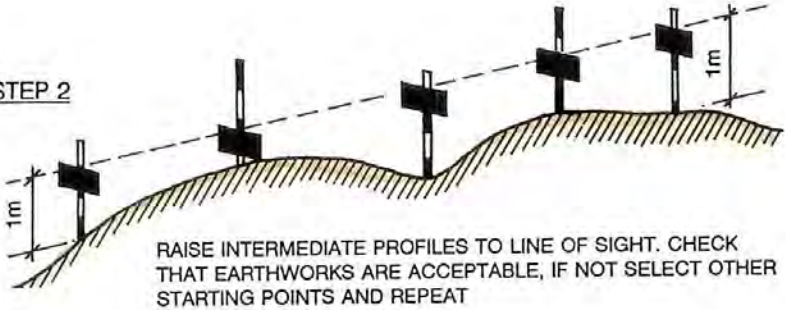
SETTING OUT A GRADIENT

STEP 1



SET FIRST AND LAST PROFILES AT 1 m ABOVE REQUIRED FINISHED ROAD LEVEL, INTERMEDIATE PROFILES RESTING ON GROUND

STEP 2

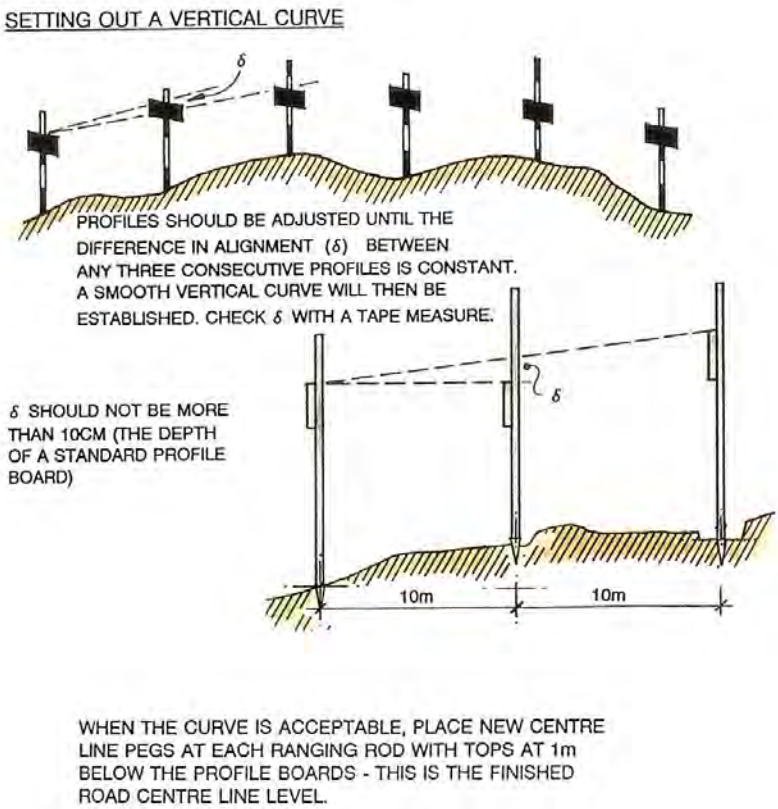


RAISE INTERMEDIATE PROFILES TO LINE OF SIGHT. CHECK THAT EARTHWORKS ARE ACCEPTABLE, IF NOT SELECT OTHER STARTING POINTS AND REPEAT

STEP 3

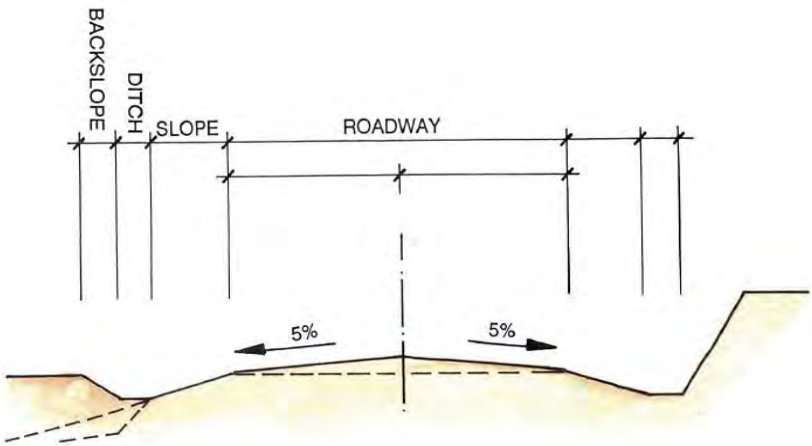
PLACE NEW CENTRE LINE PEGS AT EACH RANGING ROD WITH TOPS AT 1 m BELOW THE PROFILE BOARDS - THIS IS THE FINISHED ROAD CENTRE LINE LEVEL .

Check that the amount of earthworks at each centre line (finished level) peg is acceptable, or repeat the procedure using different assumptions.



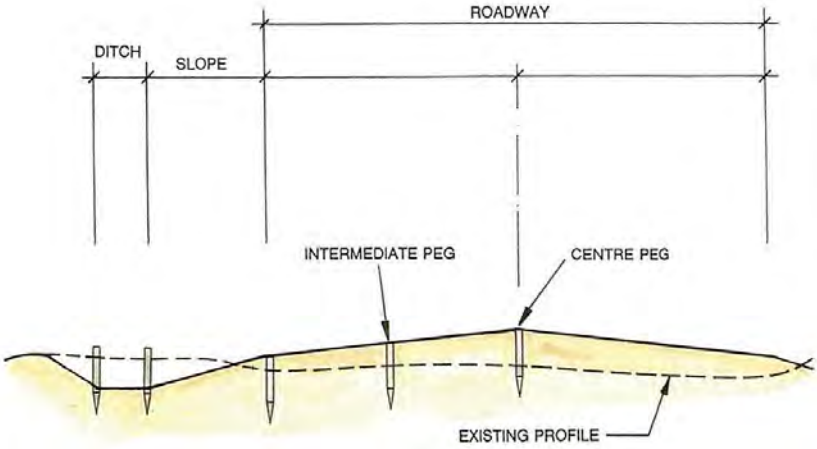
Once the centre line level pegs are fixed, set out the pegs for the edge of the roadway and both sides of the ditch using the tape measure, camber board and spirit level for the required road cross section.

Pegs should be driven in to the required finished cross section level, or a fixed height above.



EXCAVATE DITCH AND SLOPE

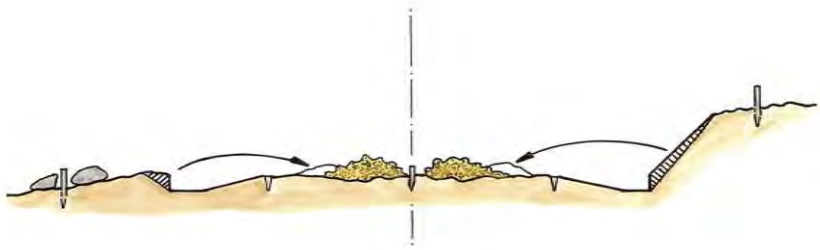
- Material is excavated from the ditch and slope area and used to form the camber until the required shape of ditch and slope is achieved.
- Check shape with the ditch and slope template, and spirit level.
- If too much material is excavated, discard the surplus material well beyond the side drain.
- If the filling placed is greater than 15 cm deep, then it is preferable to spread and compact the fill material with rakes and hand rammers or a hand/animal drawn roller in 15-20 cm layers.



DITCH AND SLOPE TEMPLATE

EXCAVATE BACKSLOPE

If insufficient material is excavated to form the camber, dig additional material from the backslope or from beyond the side drain.



CAMBER FORMATION AND FINAL COMPACTION

- Continue adding material to the camber to achieve the required profile after compaction.
- Stringlines stretched directly and diagonally across the running surface between the setting out pegs can be used to check the shape.
- Compact the fill material to the final profile, preferably using a hand or animal drawn roller.
- If a roller is not available, use hand rammers or the tyres of any vehicle to uniformly compact the soil across the roadway width.

The shaped and compacted earth road surface is a suitable foundation on which one of the surface options can be constructed directly.

Gravel Road

Defect 13: Road Surface potholed

Development, if neglected:

Gravel surface loss increases. Road becomes very rough, slowing and damaging traffic, and may become waterlogged or impassable.

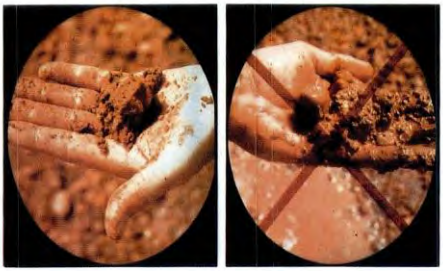
Maintenance Activity

- **110** **Spot Repair – Selected Material**
- **111** **Spot Repair – Crushed Aggregate**

Potholes and ruts should be repaired with materials similar to the surrounding surface. This can be either selected gravel material (110) or crushed stone aggregate (111) with sufficient fines to bind the material together.

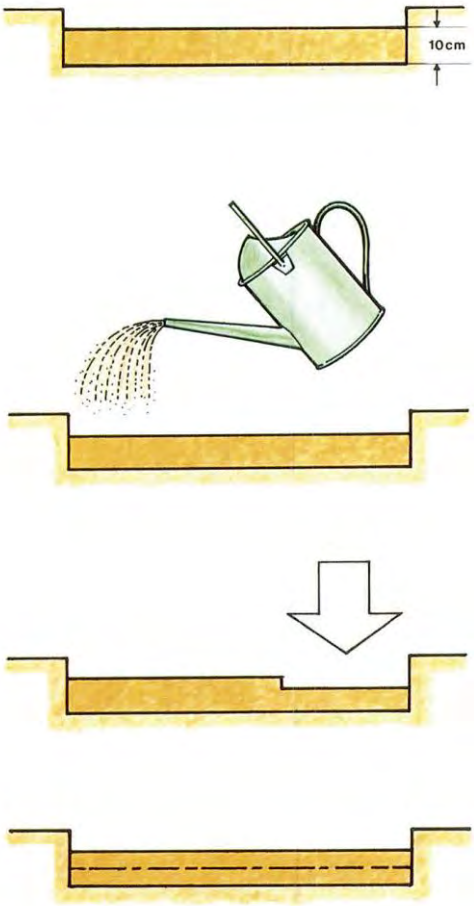
- Loose material and standing water is brushed from the pothole or rut to be patched.
- Large or deep potholes should have their sides cut back to be vertical and to reach

sound material.



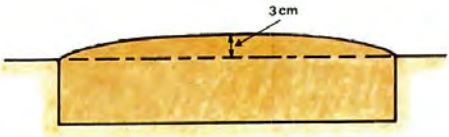
– The moisture content of the material can be checked quickly by squeezing it in the hand. If the material is wet enough to stick together, it is suitable for use. If water runs out of the material, it is too wet and should not be used.

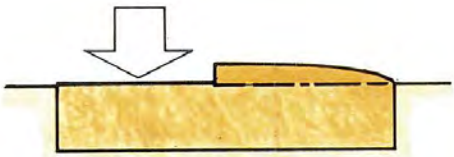
– If the material is dry, the area to be patched should be sprinkled with water and water should also be added to the patching material.



- The area is filled with gravel to a depth of about 10 centimetres.
- If the material is dry, it should be sprinkled with water to help compaction.
- The layer is then compacted using the roller or hand rammer.

– In this way the thickness of the patch is built up in layers.

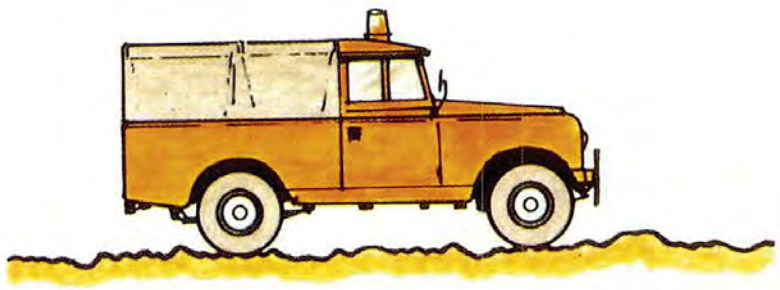




– Finally, the patched area is filled evenly with the gravel to approximately 3 centimetres above the level of the surface and is spread and raked to the correct shape.
3 centimetres is approximately the thickness of a rake handle.

- The patch is then compacted using the roller or hand rammer to give a surface which is only slightly above the level of the surrounding road to allow for further traffic consolidation.
- Both large or small areas to be patched are repaired in the same way, the rammer is used for the smaller potholes. The roller if available is used for larger areas, although the hand rammers will still be required for the corners and short edges.
- Patching work started must not be left unfinished overnight. At night the site should be made safe for traffic and all signs and obstacles removed from the road.

Defect 14: Road Surface rutted or uneven, and does not drain to edge (Minor: <3cm)



Development, if neglected:

Gravel surface loss increases. Road becomes very rough, slowing and damaging traffic.

Maintenance Activity

- **220 Blade Gravel Road (light)**

Light grading may be carried out with a motor grader or a tractor towed grader to correct minor defects on the gravel road surface such as corrugations, shallow ruts and flat camber. The task may also be achieved using labour with handtools.

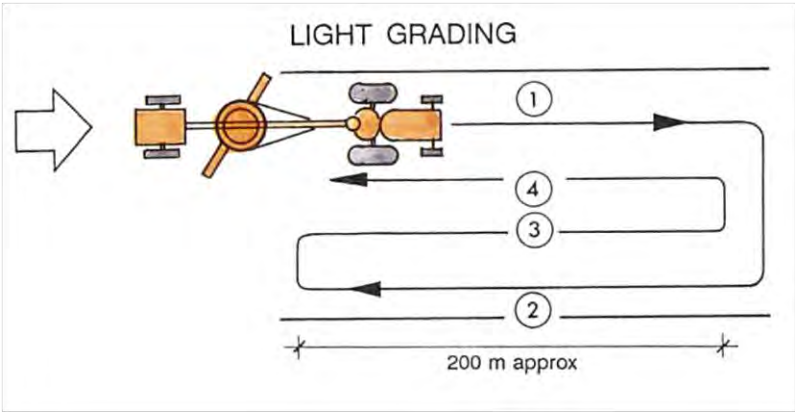
a) Light reshaping, Manual Method

- The surface material may be loosened, trimmed and reshaped with a pickaxe, hoe or mattock and rakes to form the required camber and crossfall.
- The shape is checked with the camber board and spirit level.

- If gravel stockpiles are provided, any local depressions are filled with material transported in a wheelbarrow, pannier or other device.
- The loose material is compacted with the hand rammer.
- Pegs and string lines can be used to help to achieve the correct shape and camber.

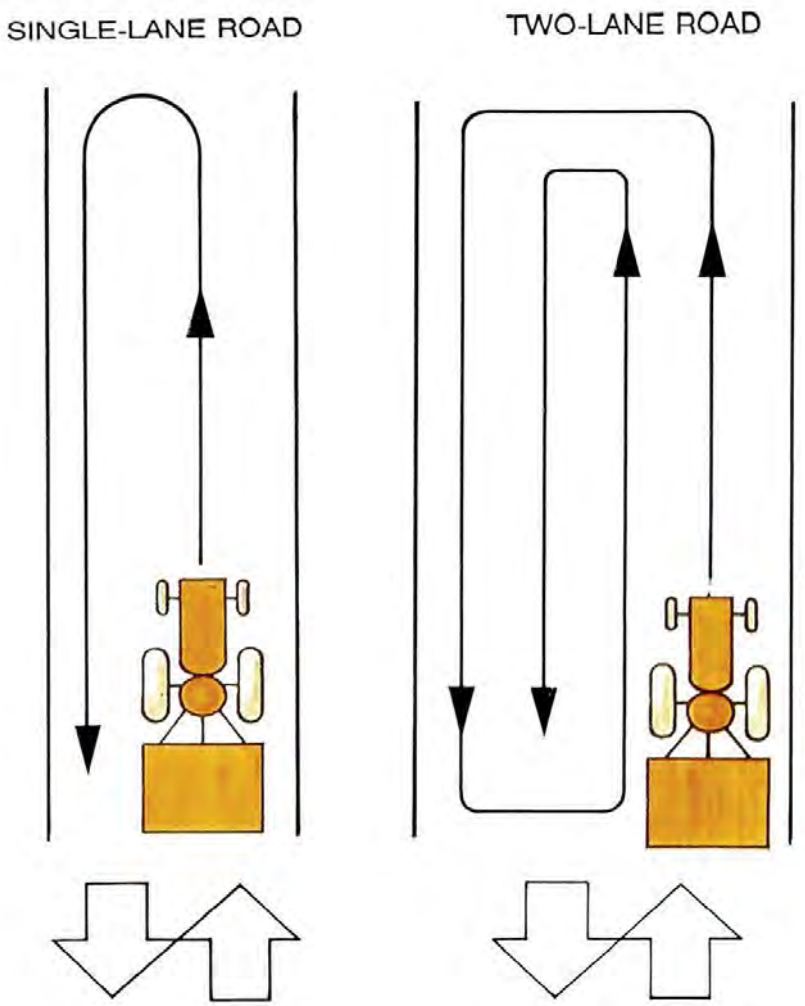
b) Light reshaping, Mechanised Method

The motor grader or tractor towed grader is used to draw the surface material back to the crown of the roadway. Normally only 4 passes will be required to achieve this minor reshaping. It is best carried out during the rains when there is sufficient moisture in the material for reconsolidation under traffic, so that expensive watering and compaction operations will not be required.

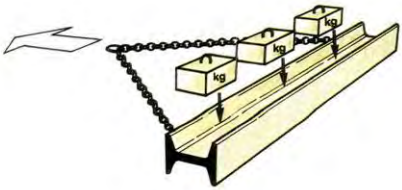


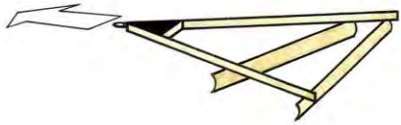
Minor corrugations can be dealt with by using a low cost drag towed by a tractor or other vehicle.

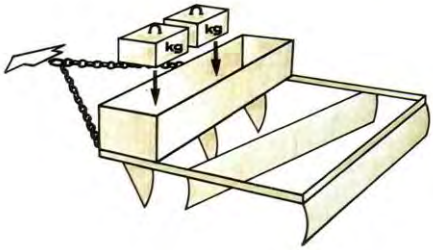
Drags can be made cheaply from old tyres or various arrangements of discarded steel sections.


SINGLE-LANE ROAD
TWO-LANE ROAD

- The tractor tows the drag at up to 5 km/hour depending on the type of drag and on the type and condition of the road surface.
- The length of pass should be as long as possible.
- The number of passes needed will depend upon the conditions and the width of the road.
- The equipment should work in the same direction as the traffic flow.







- By adjusting the length of each towing chain, a degree of lateral material redistribution may be achieved.
- DO NOT drive too fast or the drag will jump over the surface irregularities and raise a lot of dust, it will also cause a hazard to traffic.

IMPORTANT NOTE ON 'BLACK COTTON' SOIL

Expansive clay (often referred to locally as black cotton soil), is a major challenge for road works and is found extensively in the north eastern part of the country. The soil is capable of taking up large qualities of water in the rains, or if soaked, with a corresponding almost total loss of strength. In the dry season it will shrink with extensive cracking. This gives rise to serious stability problems in road foundations, for road pavements and structures.

There are a number of proven techniques for treating these soils. Unfortunately, these are all expensive in the context of South Sudan Low Volume Roads.

For LVR with a black cotton soil surface, the most effective and cheapest approach is to ensure that the road camber and drainage system are well maintained, and to PREVENT traffic from passing over the road when it is raining or soaked. This can be achieved naturally by the steep camber itself, or by installing road barriers to prevent vehicle passage during the rain, and immediately after. Usually this can be achieved by agreement between the road users and community on a Low Volume Road.

With an effective and ***maintained*** *camber and drainage system the road surface will normally drain within a number of hours after the rain ceases and regain sufficient strength to allow vehicles to pass without destroying the road surface.*

Defect 15: Road Surface rutted or uneven, and does not drain to edge (Major: >3cm)

Development, if neglected:

Road becomes very rough, slowing and damaging traffic. Water ponds on road surface. Gravel surface loss increases and danger of total gravel layer loss and road being impassable.

Maintenance Activity

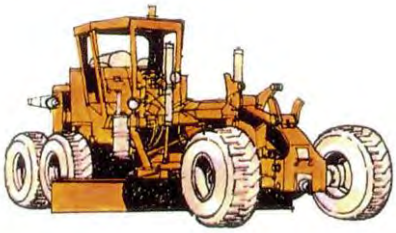
- **221 Blade Gravel Road (heavy)**

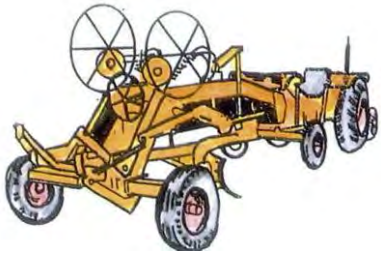
Heavy grading may be carried out with a motor grader or a tractor towed grader. However the task will also require towed or self-propelled watering and compaction equipment. The task may also be achieved using labour and hand tools by adapting the methods of Maintenance activity **112**.

Preparation

Patching (Activity **110** or **111**) of large potholes or depressions should be

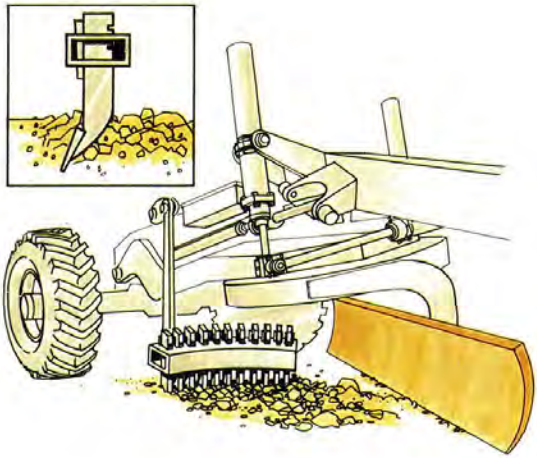
carried out in advance of the grading. Areas of standing water should be drained. This preparation will ease the work and make the resulting surface last longer.





Scarifying

Using a motor or tractor towed grader it may be necessary to scarify the existing surface to cut to the bottom of any surface defects and loosen the material for reshaping.



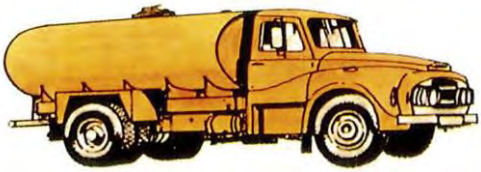
Machine Attendants

These help direct traffic and grader turning, and remove large stones and other unwanted material from the path of the grader.

Grading

The grader works on one side of the road at a time and works in passes about 200 metres long to convenient and safe turning points. Heavy Grading will require additional passes to achieve the required camber. Work should be completed on one side of the road at a time. An even number of passes should be used to avoid a flat finished crown. Normally initial cutting passes are required to bring material in from the edges of the road. Spreading passes redistribute the material away from the crown. The initial passes cut to the bottom of the surface irregularity and deposit a windrow just beyond the centre line.

Watering



The towed or self-propelled water tanker sprays the windrow with water, if required. The windrow is spread back across the road depositing all the material to give the correct camber. A second application of water may be required to obtain the correct moisture content for compaction.

Cambering

The aim should be to develop a proper crown on the road. The road should be cambered to fall away from the crown at a rate of about 6 to 7 cm for each metre from the centre of the road before compaction. This should achieve a crossfall of about 4 to 6 cm per metre (4 to 6%) after compaction. If there is insufficient camber, water will not drain easily from the surface of the road, potholes will form and the road will deteriorate quickly. This is particularly important on gradients, where the rain water tends to run along the road forming erosion channels.

Do not make a final pass down the centre of the road with the grader blade horizontal. This flattens the centre of the road and causes water to pond leading to rapid deterioration of the surface.

Do not leave a windrow on the road overnight as this is a danger to traffic.

Compaction

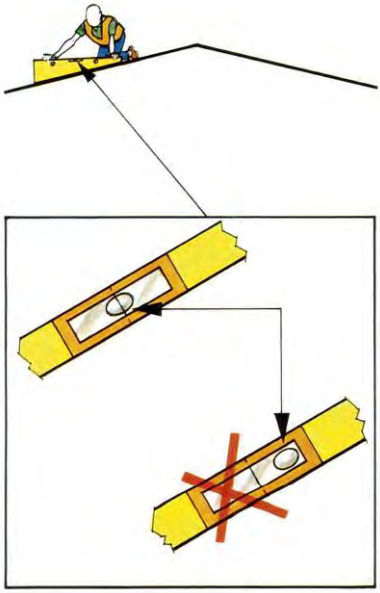
When towed, self-propelled compaction plant is being used, it must follow close up behind the grader, but only on sections where grading has been completed. Usually about eight passes of a roller will be needed to achieve full compaction (less passes with vibration), working towards the centre of the road. Shoulders are treated as part of the running surface.

Junctions and Bends

Graders must not park up near junctions or bends where they will be a danger to traffic.

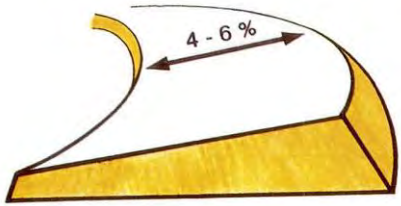
Check the Camber

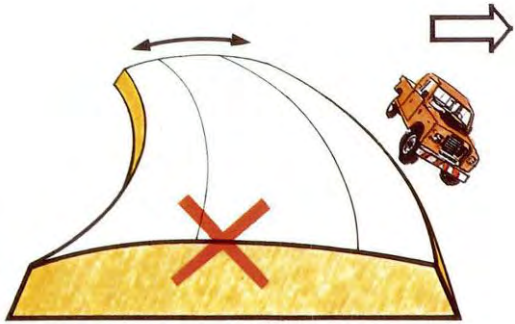
Camber should be checked with a camber board at about 100 metre intervals along the road. To use the camber board place it on its edge across the road with the shorter end pointing towards the centre line. Check the level bubble. If it is central, the camber is correct. If it is not central, the camber is either too steep or too flat and further grading and compaction are required.



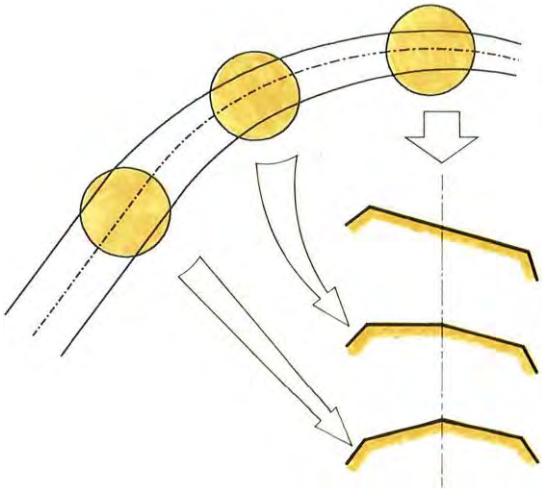
Superelevation

On bends the surface must be straight (at 4-6%) from shoulder to shoulder with the outer shoulder higher. This is called superelevation. This is because any crown on a bend can be very dangerous to traffic. The superelevation must be retained for the complete length of the bend.





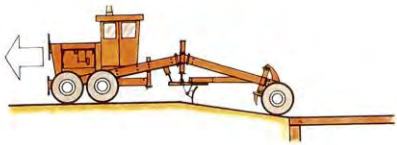
On the transition at each end of the bend into the straight sections, the superelevation should be gradually reduced until the normal cross section shape with about 1 in 25 to 1 in 17 (4-6%) crossfall is obtained again.



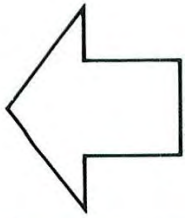
Structures

The shape of the road must be maintained over culverts to avoid a hump. Material should be brought in if necessary from either side of the culvert to maintain a cover to the top of the culvert of at least 3/4 culvert diameter.

Bridge decks should be kept free from gravel. Loose material should be swept away by the attendants. It is important to have smooth approaches to the bridge. They should be smoothed out using the back of the blade with the grader working in reverse, or by hand.



Blade position



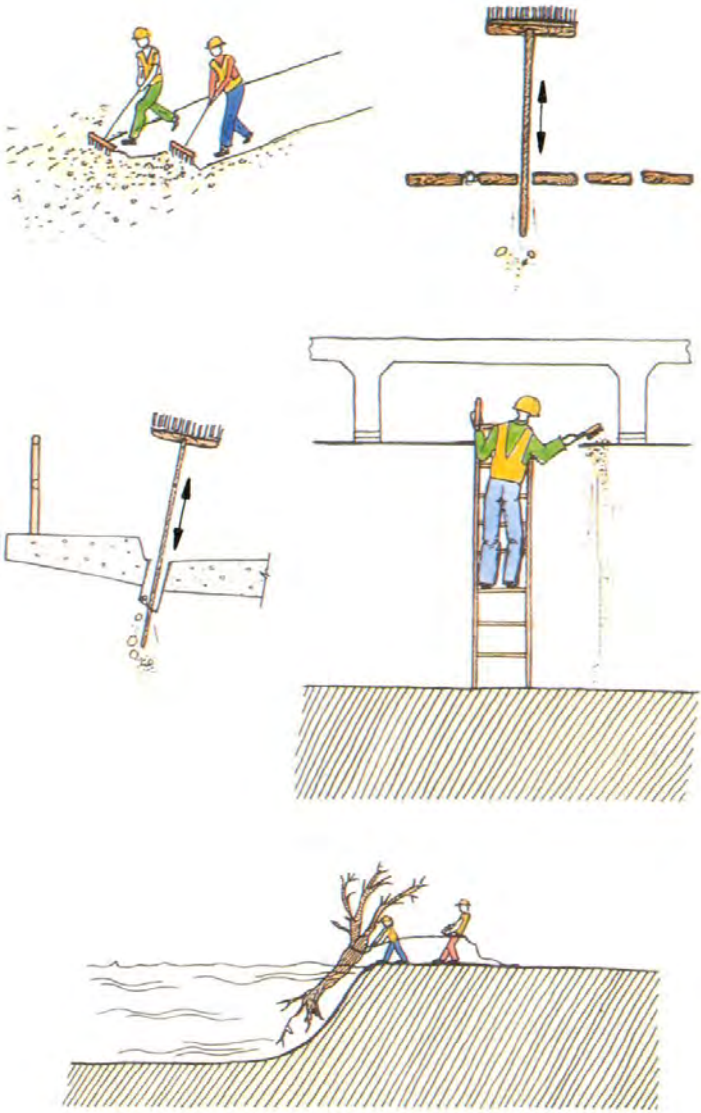
For most grading work, the cutting blade is set to be vertical.

For cutting hard surfaces, the cutting blade should be set back at the top to give the most effective cutting angle. Scarifying passes should also be made before cutting.

For spreading, the cutting blade should be set forward at the top.

STRUCTURES

Defect 16: Debris or Vegetation affecting or endangering Structure



Development, if neglected:
Structure may be damaged or become impassable

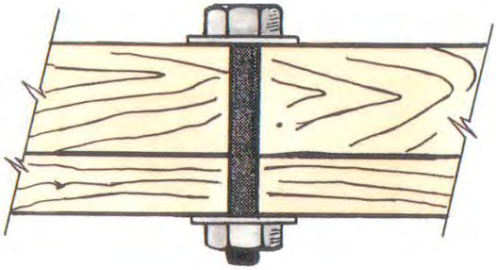
Maintenance Activity

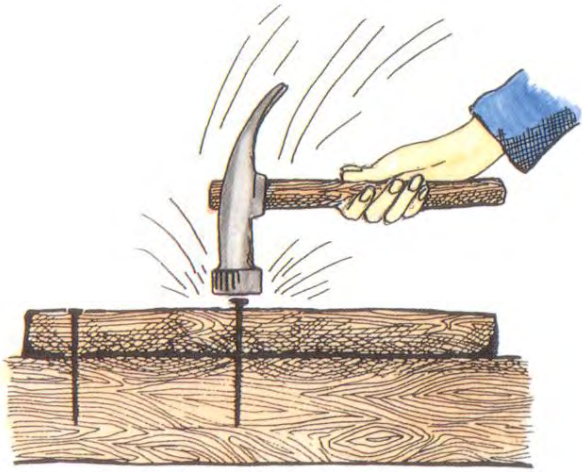
- **400 Cleaning, Clearing, Sweeping, De-silting, Unblocking or Removal of vegetation or flood/wind borne debris (Structure/inlets/outlets)**

Debris can be a hazard to traffic, or can cause blockage or turbulence at a structure causing erosion and damage. It can be expected that each year there will be an accumulation of debris from road users, waterborne and flood flows, or normal vegetation growth, which should be cleared. This is best carried out in the dry season in preparation for the structure to function properly in the rains.

All debris should be disposed of safely so that there is no further risk to traffic or structure.

Defect 17: Connectors/fixings are loose/damaged/missing





Development, if neglected:

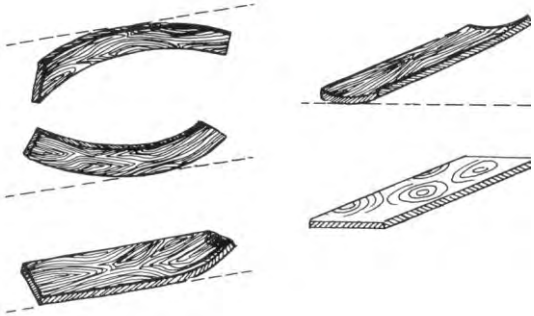
Structure may be damaged or become impassable

Maintenance Activity

- **401 Repair of Loose/missing connectors/fixings**

Particularly on timber or steel structures, the fixings may become loose or be damaged by traffic. If unattended this can lead to part or all of the structure being damaged. Annual inspections should check all components of the structure to ensure that the fixtures and fittings are secure and functioning as intended. Any necessary remedial work should be arranged.

Defect 18: Planks/Kerbs are damaged/missing



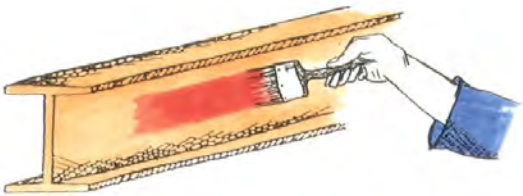
Development, if neglected:
Structure may be damaged or traffic hazard may develop

Maintenance Activity

- **402 Replace damaged or missing Planks or Kerbs**

Particularly on timber structures, the running boards or kerbs may be damaged by traffic, may work loose, or be subject to insect attack. Any damaged, loose or missing components should be re-fixed or replaced.

Defect 19: Paintwork defective or damaged



Development, if neglected:
Structural components may corrode and weaken/damage structure

Maintenance Activity

- **403 Paint main or minor parts of structure/furniture**

Paint will deteriorate with age and its protective function for steelwork may be impaired. Paintwork may need to be renewed from time to time. Signs may require to be repainted. Any loose or corroded material should be removed by wire brushing or paint remover before applying new paint. Ensure that a suitable type of paint is used.

Defect 20: Danger or evidence of insect or moisture attack of timber components

Development, if neglected:

Structural components may weaken/damage structure

Maintenance Activity

- **404 Apply wood preservative or insect treatment to timber components**

Timber components will require to be re-treated from time to time to preserve them. Any evidence of insect attack should be investigated and suitable treatment of the timber carried out. If timber components become soft or rotten, they should be carefully replaced under the supervision of an Engineer.

Wood preservation of structural timber can only be thoroughly and reliably achieved by pressure impregnation where the preservative liquid is injected deep into the timber. When pressure treatment of replacement sections cannot be employed, apply a superficial treatment. This method is only of very limited value and cannot be regarded as permanent, especially if the wood comes into contact with the soil or is used in moist climates.

A suggested procedure for superficial treatment is as follows, working with protective gloves and clothing:
1. Apply the wood preservative) with a paint brush.
2. Ensure the preservative completely covers the wood surface and ends, and that every crack is also filled with oil. Brush-in at the same time. No part should be left untreated as fungi could then easily enter.
3. Allow the first coat time to dry.
4. Repeat a second application in the same manner.
5. When the surface of treated wood has been damaged by handling, transport, bored-bolt holes, or sawing, apply oil treatment to the exposed surfaces as above before installing in the bridge.
6. After brushing work is completed, clean all brushes and containers with solvent.

Wash all traces of preservative where it comes in contact with the skin!

Defect 21: Masonry or concrete or joints defective (minor)

Development, if neglected:
Structure may become damaged by water penetration/seepage

Maintenance Activity

- **405 Pointing or Repair of Masonry/Concrete**

Minor damage to concrete, masonry or pointing may be repaired by re-pointing with sand-cement (4:1 ratio) mortar. If there is evidence of movement in the structure which may have caused the defect to occur, an Engineer should be advised to check the condition of the structure.

For further guidance refer to **Defect 8** Repairs (Page 48).

Defect 22: Structure Furniture defective

Development, if neglected:
Components may not carry out their intended function

Maintenance Activity

- **406 Repair parapets, marker posts, safety barriers, signs or other furniture**

The various furniture components can deteriorate due to weather, traffic damage or age. These are important parts of the structure and should be repaired if necessary to keep them in the intended condition and function.

OCCASIONAL MAINTENANCE – GRAVEL ROAD

Defect 23: Gravel layer too thin

Development, if neglected:

Road becomes very rough, slowing and damaging traffic. Water ponds on road surface. Gravel surface loss increases and danger of total gravel layer loss and road being impassable.

Maintenance Activity

- **317 Gravel Resurfacing (Selected Material)**
- **318 Gravel Resurfacing (Crushed Aggregate)**

Gravel surfaces wear down due to the wasting effects of traffic and weather. Loss rates can be up to 5cm thickness each year or more even on a Low Traffic Volume Road. Re-gravelling will be required when (or before) the residual thickness of gravel reduces to about 5 – 8 cm, otherwise there is a danger of vehicle wheels 'punching' through to the weaker material below. This would result in mixing and effectively the loss of the gravel layer. Great care should be taken in locating and selecting suitable gravel material. It should be obtained from a recognized approved source and meet materials specification requirements. This can be either selected gravel material, or crushed stone aggregate with sufficient fine material to bind the material together.

Gravel or crushed stone should not contain any pieces larger than 3cm, as this will seriously affect performance. 'Oversize' pieces should be hand-picked or 'screened' out. Due to the high cost of re-gravelling, technical advice should be obtained on sources and material suitability. It is likely that re-gravelling will be very expensive if the material has to be hauled more than 10km, and other types of road surface may be more economical.

Diversion?

Wherever possible, before the re-gravelling work starts, a diversion should be opened up adjacent to the road. If traffic is diverted from the work site, it will enable the job to be carried out more efficiently and safely.

Quarry or Borrow Pit

Before the regravelling work starts, gravel should be tested for compliance with specifications and stockpiled at the quarry or borrow pit. It may also be helpful to start hauling the material to site.

Plan the quarry excavations and stockpiles so that:

- the quarry can be fully exploited with removal of the maximum amount of good gravel,
- the overburden is stockpiled so that it will not hinder future extension, and that it can be used to reinstate the quarry,
- the best material is taken, where gravel quality is variable within the quarry,
- material is stockpiled to minimise segregation,
- environmental damage by poor drainage and erosion is minimised both during and after exploitation of the quarry.

The quarry layout should:

- permit efficient excavation and stockpiling of gravel,
- allow the trucks, tractor and trailers or other haulage vehicles to enter and leave without obstructions.

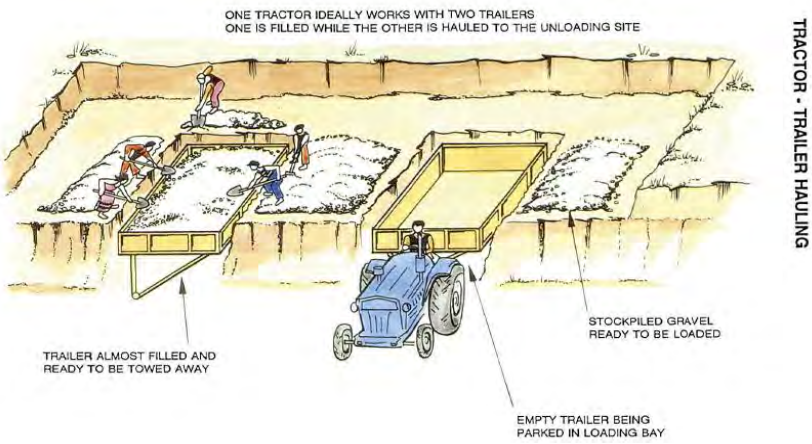
Repair the quarry access road, if necessary, to ensure safe passage of haulage vehicles.

Site Preparation

Traffic warning signs should be place at either end of the re-gravelling site.

The existing road surface must be graded-off or reshaped by hand to provide a firm regular surface on which to work. Where possible, the edges should be 'boxed' to provide lateral support for the new gravel. The graded/reshaped surface should be watered and compacted. The camber should be checked with a camber board and the road level should fall 4 to 6 cm for each one metre width of road (4-6 %). The road drainage system should be checked and repaired if necessary (see Drainage defects and activities), otherwise the performance of the new gravel surface will be affected.

At the quarry or borrow pit, the bulldozer or excavation labourers should have stockpiled sufficient gravel for the work. The excavating and stockpiling of gravel should create low, broad heaps to prevent segregation of the coarser material.

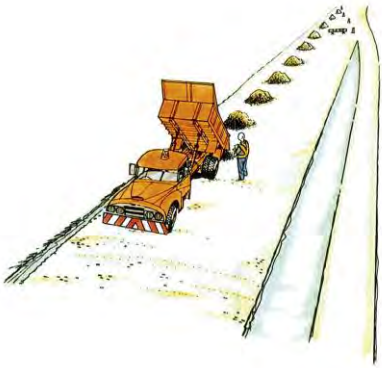


Gravelling operations

When the initial grading/shaping of the road surface is complete, the loader or the quarry labour should start to load the tippers or trailers with gravel for transport to the re-gravelling site.

The supervisor at the quarry should ensure that gravel is taken from the correct stockpiles and that the trucks/trailers are loaded correctly. Tippers or tractor trailers should always circulate continuously between the quarry and the site. Loading resources should be adjusted to try to keep the haulage equipment working continuously.

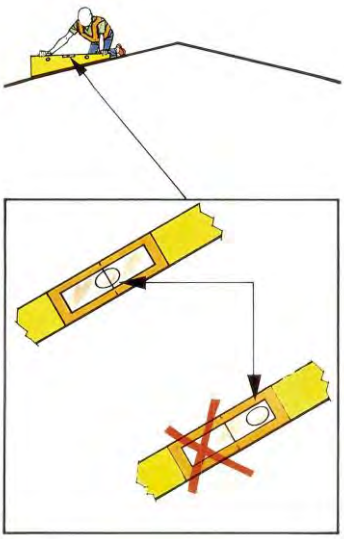
- Dumping should start at the far end of the site so that the heaps of gravel do not impede tippers or other haulage vehicles delivering later loads.
- Material should be dumped on one side of the road only.
- Loads should be placed at the correct spacing as instructed by the supervisor, necessary to give the required thickness of gravel over the complete road width after compaction.



- If the road is not closed, material should be dumped on the shoulder, or dumped and spread immediately by labour.
- The tankers or towed bowsers should have filled up with water using the pump and then have driven to the site.
- Initially the existing road surface is sprayed with water.
- Spreading of the gravel can start when there is a working length of about 200 metres of dumped material if using a motor or towed grader. If spreading is by labour, the gravel can be spread as soon

as it is dumped, or even unloaded by labour if non-tipping haulage equipment is used.

- The material is alternately spread by the grader/labour and watered with the tanker/bowser until its moisture content is correct for compaction.
- The amount of water to be added must be determined by moisture content tests on site or by the supervisor.
- The tankers/bowsers circulate continuously between the site and the source of water.
- The new material is now graded or spread by labour to produce a camber of 4 to 6 cm for each one metre width of road (4 to 6 %). Guide pegs and stringlines should used if labour spreading is used.



- The camber should now be checked with the camber board at approximately 100 metre intervals along the road for machine spreading and every 10 metres if labour is used.
- To use the camber board, place

it on its edge across the road with the shorter end pointing towards the centre line. Check the level bubble.

- If it is central, the camber is correct.
- If it is not central, the camber is either too steep or flat and further grading/manual reshaping, and compaction are required.
- When the correct camber has been achieved, compaction can start using a self propelled or towed roller, or a pedestrian vibrating roller for labour works.
- Water should not be added during rolling as the material may stick to the wheels or drums.
- Rolling should start at the edge of the road and work towards the middle. The roller should aim to progress from section to section at the same rate as the grader or labour operations.

- Typically about eight passes of the roller will be needed to achieve full compaction. Test the placed gravel for specification compliance.
- It is possible to re-gravel without the use of water and compaction, but it is difficult to achieve satisfactory results, and subsequent gravel material loss from the surface will be faster. The watering and compaction help to preserve the investment in the gravel.

OCCASIONAL MAINTENANCE – PAVED ROAD

Defect 24: Paved road pothole or surface defect

Development, if neglected:

Road becomes very rough, slowing and damaging traffic. Water ponds on road surface, speeding the deterioration and increasing risk of accidents. Road user costs increase substantially. Road may become impassable.

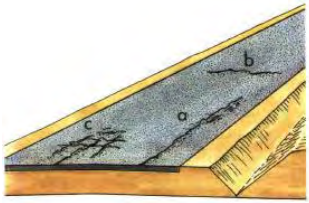
Maintenance Activity

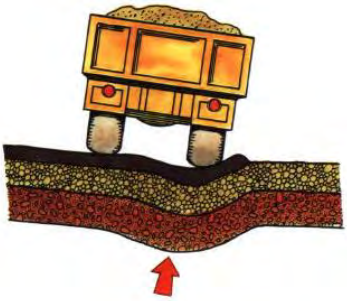
Depending on the type of paved road surface:

113a	**Spot /pothole Repair (Macadam)**
113b	**Spot /pothole Repair (Stone setts)**
113c	**Spot /pothole Repair (Mortared stone)**
113d	**Spot /pothole Repair (Dressed stone)**
113e	**Spot /pothole Repair (Emulsion chip seal)**
113f	**Spot /pothole Repair (Emulsion sand seal)**
113g	**Spot /pothole Repair (Emulsion gravel/slurry seal)**
113h	**Spot /pothole Repair (Un-mortared brick)**
113i	**Spot /pothole Repair (Mortar jointed brick)**
113j	**Spot /pothole Repair (Non- reinforced concrete)**
217	**Pothole Reinstatement (cold mix)**
219	**Pothole (Base Failure Repair)**
114	**Crack Sealing**

Although well constructed paved roads or sections should give many years of trouble-free service, from time to time defects can be expected to develop in any surface, such as:

- Cracking
- Rutting
- Potholes, or
- Edge break





These defects are normally limited in extent and can be repaired using labour, suitable hand tools and limited materials. Heavy equipment is not normally required. Compaction equipment may be required. However, light equipment or hand rammers will normally be adequate. Any work on the road surface should be signed either side of the repairs to warn road users and for the safety of those carrying out the work.

For all of the paved road surface types, the repair techniques are very similar, and consist of:

- Marking out the area to be repaired
- Excavation of the area to be repaired
- Backfilling the hole with new material

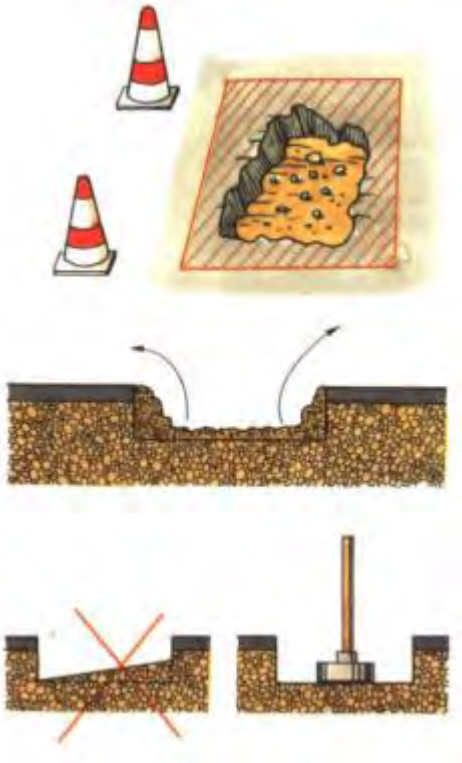
Marking out the area to be repaired

The area to be treated is marked out with chalk by drawing a rectangle around the defects.

Excavation of the area to be repaired

It is necessary to:

- remove all loose or damaged material from within the marked out area of the road surface back to a firm, sound material. Sledgehammers, crowbars, hammers and chisels may be required,
- increase the depth of the hole until firm, dry material is found and then trim the walls of the hole so that they are vertical. If water or excessive moisture is present, then arrangements must be made to drain it away from the pavement foundation,
- trim the bottom of the hole such that it is flat, horizontal and free from loose material then compact it with a hand rammer.



Backfilling the hole with new material

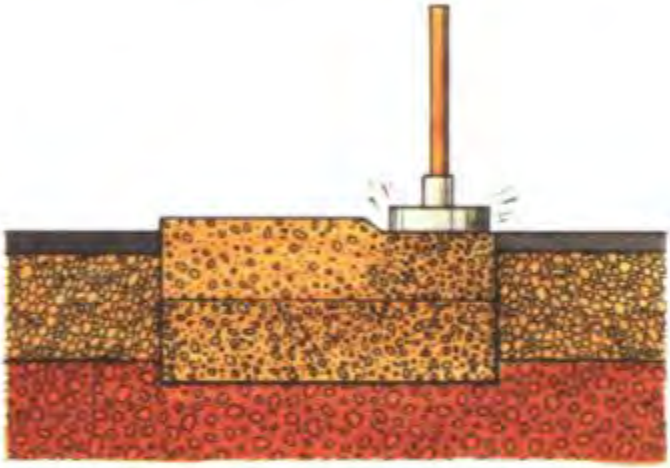
The repair will depend on the type of surface. Specifications and requirements on each material are contained in the South Sudan Specifications for new works. The same specifications and standards should be applied to the repair.

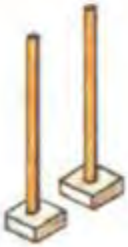
The hole is filled with a selected material to match the existing surrounding good surface and base materials. This can consist of new material, or in the case of e.g. stone paving, recycled undamaged pieces.

The material is placed in the hole and compacted in one or more layers of regular thickness depending on the depth and materials involved.

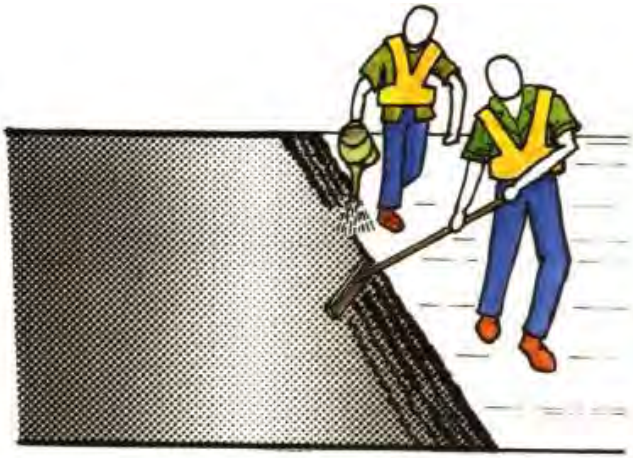
When using granular materials, generally, the last layer, prior to compaction, must have an excess thickness of about 1/5 the depth of the final layer, in order to allow for settlement on compaction.

Compaction is continued depending on the size of the excavation, using the vibrating roller, plate compactor or with a hand rammer, until the surface is level.





Porous repairs will require a seal coat to prevent penetration of water.



STRUCTURES

Cross drainage structures (bridges, drifts or culverts) usually account for a high proportion of the total cost of a road. They are the potential weak points in a road network due to the possible damaging effects of floods and high water flows being concentrated at the points where the water crosses the road. The failure of these structures would result in high replacement costs and long delays and user inconvenience due to the closure of the road. It is particularly important therefore, that sufficient attention is given to structures to ensure that they are maintained in good condition.

A bridge, culvert or other structure is an integral part of the road, and its condition will affect the level of service that the road provides. A structure should be designed so that no major repair works should be required during its 'design life' (e.g. replacement of abutments, piers or deck structural members). Eventually major works may be required such as a complete new timber bridge deck or safety barrier replacement. However, the structure should be designed to provide many years of service through its design life with only minor maintenance.

Importantly, if the maintenance is not carried out, there can be serious consequences for road users. It can result in increased safety hazards, reduced quality of service or even loss of the structure and severing of the transport link.

It is usually not possible with the resources available in developing countries to devise a 'maintenance-free structure' for a watercourse crossing. However, application of the design and construction guidelines contained in this South Sudan LVR Manual should reduce maintenance requirements to an acceptable and manageable level. Conversely, poor design or construction will result in an abnormally high requirement for maintenance, or even eventual loss of the structure.

There are a number of aspects which should be appreciated in devising appropriate management and maintenance arrangements for structures. This applies to consideration of an individual structure, or a large number constructed at various locations on a road network.

- Structures will often need no maintenance for periods of many months or sometimes even years.
- Deterioration or damage to a structure can progress slowly (e.g. corrosion, attack by insects), or suddenly (e.g. in a flood or vehicle accident).
- The need for repairs may not be obvious to road users or through casual observation from the road. However, the deterioration can progress, if not checked, to result in the need for major works at great cost and requiring substantial unplanned resource mobilisation.
- The resources for maintenance and repair of a typical structure are required intermittently, not continuously.
- It is usually most efficient to provide maintenance resources only when the structure requires maintenance or repair works.

It is important to ensure the maintenance of a structure so that it remains in its intended condition, providing the service and benefits to road users and the community that it was designed for. It is an asset that needs to be managed.

It is advisable to inspect all structures at least once each year. This is best achieved after the rains, so that any remedial works can be planned to be carried out before the next rains.

Defect 25: Random stone filling defective

Development, if neglected:
Erosion of structural protection and possible structural damage

Maintenance Activity

- **410 Repair Random Stone filling**

Random stone filling is provided to protect the structure and the adjacent areas from erosion, particularly when the watercourse is in flood condition. The stone filling may become defective due to ground settlement or erosion in flood conditions. Minor repairs can be carried out by topping up the stone with similar material to the original constructed profile. If the defects are extensive, an Engineer should be consulted to investigate the cause and plan suitable remedial works.

Defect 26: Retaining wall defective

Development, if neglected:
The road works, earthworks or structure protected by the retaining wall may be endangered and the route may become impassable

Maintenance Activity
411 Retaining Wall Repairs

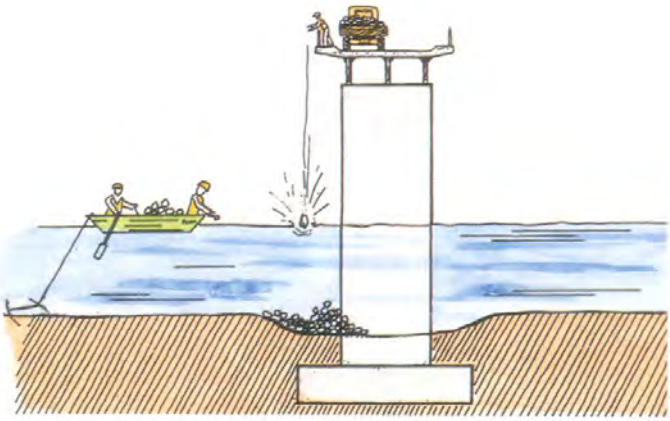
It is important to determine the cause of the defective retaining wall, which may be due to settlement, erosion, water seepage or structural failure. Any defects should be brought to the attention of an Engineer to investigate the cause and plan suitable remedial works.

Defect 27: River or stream bed scoured adjacent to structure

Development, if neglected:
Scour adjacent to the structure can cause failure of the abutments or piers and causing the structure to become un-usable.

Maintenance Activity
412 Watercourse scour repairs

Loss of riverbed material by fast flowing water at piers, abutments and wing walls is best identified and repaired at low water level or when the river bed is dry.
The scoured area should be refilled with rock using stone pieces of 10 to 30 kg weight, or heavier. The decision on stone size must be made, taking into account what is locally economically available.
In serious cases further protection, such as gabions, may be required.



IF SCOUR AREA DRIES OUT:

1. Stake out the area around the pier or wall where scour has occurred.
2. Excavate to estimated lowest scour level.
3. Place riprap stone in layers in the excavation, starting with the smaller size stone in the lowest layer.
4. Fill spaces between stones with smaller size stone.
5. Continue work layer after layer until normal bed level is reached. The top layer should contain the heaviest stones and have a flat even surface at river bed level.

IF SCOURED AREA IS SUBMERGED:

When it is not possible to place the riprap apron in regular layers due to water flow, the scour area can be filled by random filling of the scour depression.

1. Establish the extent of scour by survey, plumbing the riverbed. Use poles or marker buoys to identify the extent of the work required.
2. Using stone blocks as above, drop riprap material into the scour depression from the bridge, a boat or from the bank until the depression has been filled. Re-plumb the riverbed throughout the work to check progress.

Defect 28: Gabion walls or mattress defective

Development, if neglected:
The road works, earthworks or structure protected by the gabions may be endangered and the route may become impassable

Maintenance Activity
413 Gabion Basket Repairs

If the defects are extensive, the gabion structure, or part of it, may need to be reconstructed.

Refer to the details and description for **Defect 10**.

Defect 29: Structural Repairs of serious defects

Development, if neglected:
Serious damage to or failure of the structure. Route may become impassable.

Maintenance Activity
414 Major Structural Repairs

Structural repairs may be required for the following serious defects:

- structural timber decay, splitting or insect attack
- bulging masonry
- cracked concrete or masonry
- honeycombed concrete
- spalling concrete
- serious rust or chemical stains
- exposed or corroding reinforcement or pre-stressing steel
- damp patches on concrete
- seriously corroded structural steelwork
- damaged/distorted structural steelwork
- missing/loose rivets, bolts or other fixings
- cracks in structural steelwork
- settlement of deck, piers, abutments or wingwalls
- expansion joint or bearing defects
- erosion requiring piling works.

These major defects will require the expertise of an Engineer to assess and design/specify the remedial works in response to the scale and nature of the defects. It is likely that Plans, Drawings, Specifications and Bills of Quantities will need to be prepared for these major works.

IN SUMMARY

GOOD, REGULAR ROAD AND STRUCTURES MAINTENANCE WILL PRESERVE ASSETS AND SHOULD PREVENT ACCESS BEING SEVERED,

AND RURAL COMMUNITIES BEING ISOLATED!

11. MANAGEMENT & PRIORITIES

With limited resources, it is usually necessary to set priorities for carrying out maintenance work. Maintenance should always take priority over any route upgrading or improvement works. **Protect what you have before extending your assets and liabilities!**

Furthermore, maintenance is most effective when applied to 'maintainable' routes, that is, those with a road camber and drainage system already established. This is preferable to trying to work on un-drained tracks and sunken road sections, which will consume a lot of resources with limited impact and durability.

The usual questions are:

- Which Route?, and
- Which maintenance activity?

Route Priorities

Within the community, the routes with the higher maintenance priorities should be agreed. For simplicity and clarity it is best to divide all routes into 2 or 3 priority groups based on the following suggested criteria:

- Strategic inter-community or main road links
- Is it maintainable? That is, does it already have camber and working drainage system?
- Traffic: high (e.g. more than 25 motor vehicles/day) or low
- Population served
- Value of volume of crops extracted each year
- Serving markets, educational or health facilities

It is useful to list the routes as an Inventory of assets to be managed, as an aid to planning and management, for example:

EXAMPLE INVENTORY

Route	Length (km)	Daily traffic in motor vehicles (date of survey)	Reasons for priority	Days impassable last year
Priority A Main road to A	6.4km gravel	65 (July 2010)	Main Access, No alternative route	0
A to village B	3.5km earth with spot paving	50 (April 2010)	School and crop exports	0
Priority B A to village C	4.5km earth	20 (January 2010)	Horticultural, Key bridge	2
Village B to C	5.0km earth	12 (October 2009)	Dispensary	10
Village C to D	7.0km earth	<10 (July 2010)	Pottery, sunken sections	25

It is beneficial for this information to be displayed at prominent community locations, and updated regularly.

Maintenance Activity Priorities

Where it is possible to arrange route maintenance on a number of occasions each year, the following seasonal priorities should be made for each group of maintenance activities:

BEFORE RAINS: Drainage & Structures

DURING RAINS: Drainage & Road Surface unpaved road sections

AFTER RAINS: Road Surface paved sections & Roadside activities & Occasional maintenance, Inspect Structures.

In this way the vital road drainage system and crossings are prepared before the rainy periods and are kept functioning through the rains. The earth and gravel surfaces are most effectively maintained during the rains (provided they have not been allowed to deteriorate too much to require reconstruction) when there is moisture in the materials to help consolidate them after reshaping. Paved road surfaces will usually develop any defects during the rains and are best repaired when the drier weather comes.

Some variations to these general priorities may be applied due to local conditions.

If a route becomes blocked or totally impassable, this is no longer a maintenance problem. It will usually require the reasons to be investigated and additional resources required to re-open it. Assistance or advice may be required from MRB or local authorities.

Upgrading or Spot Improvement Priorities

Each year, and for each route, an assessment should be made of any desirable spot improvements that should be made if resources are available. These could include any of the options listed on Page 8.

Management of Structures

The maintenance works required to be carried out on a structure will range from basic seasonal clearing of silt and debris (Regular or Routine Maintenance) to ensure it continues to function properly, through to replacement of components of the structure when they are worn out or damaged. It can be expected that ALL structures will normally require at least some basic maintenance each year.
It is necessary to set up a management system to ensure that the structure stays in a condition that it is able to carry out its function in a safe manner.

In essence this 'system' should identify **defects** and when work needs to be carried out. From this assessment the maintenance funding and works can be arranged and supervised to ensure that the maintenance is completed satisfactorily.

A system of inspections is required to identify any damage or deterioration of the structure, or problems adjacent to the structure which may threaten its stability.

The key components of a structures management system are:

- An inventory of all structures (i.e. What is the asset? What are its key features? These are management records which generally do not change with time, except for new structures or after major structural changes to an existing one);
- An inspection system (to determine the condition and repair needs);
- Arrangements for specifying, arranging, supervising, recording/reporting and paying for the works. Arrangements should also be in place for checking the 'value for money' of maintenance operations and expenditures.

TRL Overseas Road Note 7 (Reference 12) provides comprehensive guidelines on the inspection and documentation of inventory and condition information on structures. A paper based system is quite adequate for Low Volume Roads. Computer systems can help if the number of structures being managed is substantial and the operating environment can support the maintenance of the computer system itself, including arrangements for the on-going support, costs and skilled resources required. In a limited resource environment it can be difficult to justify and secure the recurring costs of administration, computer support personnel and inevitable software and hardware upgrades required for a computer system; i.e. there can be an undue and unnecessary dependence on external resources.

Certain maintenance activities such as de-silting and removal of debris should be carried out under a routine programme of works. For example,

before the rainy season all silt should be removed from culverts, their inlets and outlet channels. After the rains, and particularly after individual floods, silt and debris should be cleared from structures to avoid later damage due to blockages or diversion/ concentration of water.

These routine clearing operations are an ideal opportunity to carry out an inspection of a structure. With the scarcity and expense of engineering personnel, it is possible to train persons with limited education (e.g. the gang leader) to carry out inspections and to alert engineering staff to situations that require their action.

Inspections of ALL structures should be carried out after a flood situation as this is the most likely time for damage to have occurred. Particular attention should be paid to identifying any movement, especially at joints, cracking/spalling and assessing whether erosion has occurred around abutments and piers, or at the ends of aprons. Where water is permanently standing against the structure, probing with ranging rods, poles or plumb lines should be carried out to identify unseen scouring. A boat or raft may be required for this inspection.

All structures, from culverts to bridges, should receive a documented routine inspection at least once each year. As indicated above these can be carried out by relatively unskilled personnel if the appropriate training is provided. Inspection records should be carefully filed for future reference. Even a report of 'no defects' is important management information.

The management of a structure costs money and, even before a structure is built, the ongoing provision of the funds and resources for the management (including inspections), as well as the maintenance of the structure, should be assured.

11. WORK OPTIONS

There are a number of ways that maintenance work can be organised depending on the financial and human resources available, and 'in-house' capacity of the responsible authority or organisation.

In practical terms, the maintenance of Low traffic Volume Roads (LVR) will be carried out principally by labour methods with possible occasional support of intermediate or heavy equipment. The last option is often too expensive to mobilise and inefficient for remote rural road works.

All options will require appropriate levels of training and mentoring, and management arrangements.

The main work organization options are detailed in this section with their typical advantages and disadvantages. The Works Options are:

- **Option 1- Small Contractor (Private)**
- **Option 2 - Force Account**
- **Option 3- Community Group**
- **Option 4 - Length Person or Family Contract**
- **Option 5 - Compulsory/Voluntary Labour**
- **Option 6 - Hire-in equipment**
- **Option 7- Large Contractor Based System**

Option 1- Small Contractor (Private)

The small enterprises will be based in the state or local area of the road. They may be general or building contractors with established contracting experience in earthworks, masonry and concrete. They would be expected particularly to make use of local labour, and may have access to light equipment such as a small compacter, concrete mixer or tractor. This implementation option can be suitable for All Maintenance activities and for all types of road surface.

Advantages:

- Overheads lower than big contractor
- Low mobilization and demobilization costs
- Construction experience of the enterprise
- Available range of building and maintenance skills
- Local enterprise committed to the community
- Good prospects for local employment and money being injected into the community

Disadvantages:

- Time, resources and costs involved with preparing and managing the contract
- Market for maintenance works currently not developed so prices may be distorted (guideline unit costs should be available from MRB or local authorities)
- Small contractor may have to hire in some equipment
- May initially require some training/ mentoring, or a higher level of supervision than large contractors
- May have difficulty in obtaining credit for purchases, or financing cash flow
- Insufficient funds currently available to pay for this approach for all maintenance work (but may be suitable for selected works – see also Option 6)
- Risks of disputes over interpretation of contract responsibilities

Option 2 – Force Account (sometimes called Direct Labour)

This option makes use of a permanently employed and equipped workforce to carry out the maintenance work such as local road management units. This implementation option can be suitable for All Maintenance activities and for all types of surfaces.

Advantages:

- Direct response to all maintenance needs
- Rapid mobilization when funds are available
- Retain skills and experience within organization, familiarity with the network, standards, work methods
- Minimum of works documentation requirements
- Dealings/ disputes with outside parties minimized.

Disadvantages:

- In some cases no budget or funds are currently available for this option
- Difficulties in equipment procurement & the lowest initial purchase cost policy can hinder the standardization and efficiency
- Poor mobility of the workforce around the network unless transport is provided (at considerable cost)
- Paid labour and equipment may be standing if no funds available for works
- Possible low efficiency and poor management/use of available resources, poor cost-awareness
- Little pressure to try new solutions/ technologies
- High mobilization and demobilization costs if sourced from state or national level

Option 3– Community Group

The use of a group of persons based within the community and organized specifically to carry out the maintenance works under an agreement or contract with the community or local authority. This can be for a single route, or a number of routes serving the community. This approach differs from the Length person or Family contract approach only in that the number of persons expected to be

involved would be greater, and that consequently work would probably be concentrated at a particular time or times of the year. Possibility of organizing annual or regular community 'day of road action' when the whole community works on the road for nominal payment or arrangement. This implementation option can be particularly suitable for the Regular Maintenance activities.

Advantages:

- Low cost compared to most other forms of contract (due to low overheads, low mobilization and demobilization costs, absence of profit component, and by local participation)
- Can be cash or in-kind payment according to community circumstances
- Simple contract/agreement required
- Direct response to Regular maintenance needs – Rapid mobilization, or planned seasonal inputs
- Retain skills and experience within the community, familiarity with the network and any problem sections
- Close control of the works personnel
- Pride of 'ownership' for the network
- No dealings/disputes with parties outside of the community
- Employment and money/resources recycled within the community
- Employment can be targeted at poor or disadvantaged persons in the community.

Disadvantages:

- Possibly insufficient cash funds available to pay for this approach in poor communities
- Possible difficulties in controlling output and quality
- Not suitable in areas of dispersed or low population density
- No equipment capability

- May not have access to construction quality hand tools

Option 4 – Length Person or Family Contract

A contract or agreement is drawn up for an individual or family to carry out specified Regular maintenance activities on a section of road, at certain times of the year, for a payment in cash or in-kind for work on a full or part time basis.

Usually a labourer is appointed for a distinct section of road close to his/her home, typically 1 to 2 km in length. The person walks or cycles to the work site each work day. He or she is provided with all the necessary hand tools to carry out all the regular maintenance activities as instructed by the local authority. An advantage is that regular maintenance of the entire road can be arranged at all times and one person can be made fully responsible of a road section. A disadvantage is that supervision has to mobile and frequent to ensure that performance does not deteriorate.

Advantages:

- Low cost compared to most other forms of contract (due to low overheads, low mobilization and demobilization costs, absence of profit component, and by local participation)
- Can be cash or in-kind payment according to community circumstances
- Simple contract/agreement required
- Flexible approach to seasonal needs.
- Rapid mobilization by person living 'on site'
- Pride of 'ownership' for the network
- No dealings/disputes with parties outside of the community
- Employment and money/resources recycled within the community

- Employment can be targeted at poor or disadvantaged persons in the community

Disadvantages:

- Possibly insufficient cash funds available to pay for this approach in poor communities
- Possible difficulties in controlling output and quality
- Not suitable in areas of dispersed or low population density
- No equipment capability
- May not have access to construction quality hand tools
- System will degenerate if supervisor is not continuously mobile and effective in management

Option 5 – Compulsory/Voluntary Labour

The use of local (community) labour to carry out maintenance works on the roads is one of the options for maintaining community roads. The approach can be suitable for Regular Maintenance activities. If the whole community can be persuaded to attend a 'maintenance day' once or twice a year with their hand tools, there will be sufficient labour resources to carry out the necessary maintenance work under the guidance of a trained supervisor. This is the cheapest way to maintain a LVR and involves no taxation or levy to the community. Everybody contributes and benefits equitably. Wealthier inhabitants, traders or other well-wishers could contribute hand tools, equipment hire or food to create a community occasion.

Advantages:

- No financing or cash accounting involved
- In richer communities, individuals can elect to pay cash instead. This can provide funding for materials, handtools and equipment hire, or even paid labour
- Minimum of works documentation requirements

- Direct response to all maintenance needs
- Rapid mobilization
- Retain skills & experience within community
- Direct supervision of works
- Pride of 'ownership' for the network
- No dealings/disputes with outside parties

Disadvantages

- All persons contribute equally, whether rich or poor
- Can be a severe burden on the community's poorest persons
- Difficulties in controlling output and quality
- Not suitable for work during the agricultural 'high' season
- Not suitable in areas of dispersed or low population density
- Few prospects for PAID community employment or money being injected into the community
- No equipment capability
- May not have access to construction quality hand tools
- May initially require some supervisor and 'gang leader' training/ mentoring,

Option 6 – Hire-in equipment

This is an option to supplement the other options to provide equipment for specific operations such as towed grading or haulage. The funding could be provided by the local authority if available, or a benevolent trader, farmer or other well-wisher.

Option 7 – Large Contractor Based System

The employment of a large equipment-based contractor may be considered. They are usually based in state centres or Juba and their overheads, mobilization and demobilization costs and profit components would be very high. Therefore, the costs would be

extremely high and unlikely to be affordable by the community or local authority. In cases where a contractor is funded externally to construct a road, this contractor may be engaged as part of the contract to maintain the road for some years after the final construction acceptance is finalized.

12. PLANNING AND PRODUCTIVITY

It is important to plan the maintenance works according to the defect repair needs, the priorities and the resources available to carry out the works.

The following labour resource requirements were developed from research in East Africa and can be used as an outline planning guide.

OUTLINE REGULAR MAINTENANCE PLANNING FOR LVRs

Number of Person-days of work expected/km/year

Number of "wet" months	Gravel <50vpd	Gravel >50vpd	Earth <50vpd	Earth >50vpd
4	40	45	45	52
8	68	75	79	88
12	100	107	115	125

NOTES:

i Number of "wet" months per year are with rainfall >25mm.

ii Estimates assume 'maintainable' road with proper camber and drainage system and gradients <6%. Not applicable for problem soils such as 'black cotton'.

iii Does not include Occasional works such as re-gravelling.

With good record keeping a similar table can be developed for each community. Equipment inputs may be required for materials haulage and towed grading. Earth and gravel roads require reshaping/grading typically between 1 and 4 times per year. These estimates will help to make resource and cost estimates for each road each year.

Productivity Targets

To plan and manage maintenance works it is useful to have productivity Standards, Norms or Targets. These need to be flexible considering the variable nature of LVR maintenance works, experience of the supervisor and workforce, and whether the work is carried out on a paid or voluntary basis. Development of local Norms or Targets can take considerable time to achieve. The following Targets were developed from research in East Africa and practice in Southern Africa, and can serve as a reference point. The standards were developed under close supervision conditions, with a well trained workforce. They represent the best productivities that can be achieved with a well organised and managed workforce. They should therefore be as targets to be worked towards. It is expected that under normal conditions 60 – 80% of the productivity standards should be achieved. Good record keeping can allow local productivity standards to be developed over time.

PRODUCTIVITY TARGETS PER PERSON-DAY			TASK DIFFICULTY				NOTES
CODE	MAINTENANCE ACTIVITY	UNIT	1	2	3	4	
110 111	Spot Repair – Selected Material/Aggregate	wheel barrows / day	25	18	13	8	Difficulty = Hauling distance from stockpile 1. no haul 2. up to 100m 3. 100m to 200m 4. over 200m
112	Reshape & Compact Earth Road Camber	route m/day	70	50	-	-	Difficulty = Type of reshaping over road width 1. (Light) up to 75mm cut 2. (Heavy) over 75mm cut
121	Culvert Cleaning	As Shown	4 Culverts /day	1 Culvert /day	2 Days /Culvert	4 Days /Culvert	Difficulty = Silt Depth in Culvert barrel 1. up to 1/4. 2. 1/4 to 1/2. 3. 1/2 to 3/4. 4. over 3/4. Tasks for 600 dia. Culverts 7m. long
122	Ditch Clearing - Manual (Culvert outfall)	m/day	55	40	25	-	Difficulty = Silt depth 1. up to 10cm 2. 10 to 20cm 3. over 20cm
122	Ditch Clearing - Manual (Turnout drains)	m/day	60	45	30	-	Difficulty = Silt depth 1. up to 10cm 2. 10 to 15cm 3. over 15cm
122	Ditch Clearing - Manual (Side drains)	m/day	Wet areas 65 Dry soft soil 55 Dry hard soil 30	45 40 23	30 30 18	-	Difficulty = Silt depth 1. up to 10cm 2. 10 to 15cm 3. over 15cm
123	Repair Erosion Damage (Selected Fill in drains)	m/day	Wet areas 100 Dry areas 100	80 50	60 23	-	Difficulty = Depth of erosion 1. up to 15cm 2. 15 to 30cm 3. over 30cm
126	Dry Masonry Repair	m/day	7	4	-	-	Difficulty = Type of repair 1. minor repairs 2. major repairs Task for linear metres of dry stone wall
128	Build wooden/stone scour check	No/day	5	7	-	-	Difficulty = Type of scour check 1. wood 2. stone

PRODUCTIVITY TARGETS PER PERSON-DAY			TASK DIFFICULTY				NOTES
CODE	MAINTENANCE ACTIVITY	UNIT	1	2	3	4	
131	Bush clearing - light	m/day	425	260	190	-	Difficulty = Width of bush 1. up to 1.0m 2. 1.0 to 2.0m 3. over 2.0m
131	Bush clearing - dense	m/day	275	225	175	-	
132	Shoulder Rehabilitation (manual)	m/day	100	80	65	-	Difficulty = Depth of erosion 1. up to 10cm cut 2. 10 to 15cm cut 3. over 15cm cut
133	Plant grass and water	m/day	100	80	65	-	Difficulty = Planting width 1. up to 0.5m 2. 0.5 to 1.0m 3. over 1.0m
134	Cut grass - light	m/day	Wet areas 425 Dry areas 310	260 230	190 170	-	Difficulty = Width of grass cutting 1. up to 1.0m 2. 1.0 to 2.0m 3. over 2.0m
134	Cut grass - dense	m/day	310	240	175		
220	Blade Gravel Road (light)	route km/day	10	-	-	-	Difficulty = 4 passes up to 3cm of cut. Excludes mobilisation & demobilisation
221	Blade Gravel Road (heavy)	route km/day	4	-	-	-	Difficulty = 8 passes more than 3cm of cut. Excludes mobilisation & demobilisation

13. FURTHER ADVICE AND ASSISTANCE

Documentation

The following documents and publications may be accessed for further information. Some of these documents may be accessed or downloaded free of charge from www.gtkp.com .

1. Ethiopian Road Authority, LVR Design Manual, 2011
2. Ethiopian Road Authority, Maintenance Technical Specifications
3. Ethiopian Road Authority & Intech, Intermediate Technology Roadworks Equipment, Final Report, November 2010
4. Gongera K & Petts R C, A Tractor and Labour Based Routine Maintenance System for Unpaved Rural Roads, 2nd Edition, 2003
5. ILO, Guide to Tools and Equipment for Labour Based Road Construction, 1981
6. Intech Associates & MOPW Kenya, Road Maintenance Manual, 1992
7. Intech Beusch & Ministry of Roads and Public Works, Operations Manual Roads 2000, 2005
8. I&D Consult & MOPW Kenya, Headmans Handbook for Maintenance, 1991
9. Jones T E & Petts R C, Maintenance of Minor Roads in Kenya, TRB Fifth International Conference on Low Volume Roads, USA, 1991
10. OtB, Low Volume Rural Road Surfacing and Pavements - A Guide to Good Practice, 2013
11. Petts R C, Handbook of Intermediate Equipment, 2012
12. Transport and Road Research Laboratory, Overseas Road Note 7, Volume 2, Bridge Inspector's Handbook, 1988
13. World Road Association (PIARC), International Road Maintenance Handbook, 4 Volumes, 1994 and revisions

Knowledge Sources

1. Global Transport Knowledge Partnership, www.gtkp.com, info@gtkp.com
2. Transport Research Laboratory, UK
3. CSIR, South Africa
4. Indian Roads Congress
5. Various road sector Technology Transfer Centres

Expertise

1. Ministry of Roads and Bridges , Juba
2. State Road Authorities
3. Locally operating agencies (in 2012 these included UNOPS, WFP, USAID and some specialist Engineering Consultants).

Financial or other support

It is appreciated that communities and local authorities have very limited resources and funding available for improving or maintaining rural access roads. However, regional, national and international organisations may be interested to help with partial funding for cost-effective, well-targeted rural transport development initiatives which can demonstrate rural development or poverty reduction benefits.

The following organisations have previously supported rural transport initiatives. Details of their headquarter and local representative offices may be obtained from the internet.

- African Development Bank
- Arab Bank for Economic Development in Africa
- CARE
- DANIDA
- DFID, UK
- DGIS (Netherlands)

- FINNIDA (Finland)
- Helvetas (Switzerland)
- Irish Aid
- Islamic Development Bank
- Kuwait Fund
- NORAD (Norway)
- OPEC Fund for International Development
- Saudi Fund for Development
- Swiss Development Cooperation (SDC)
- SIDA
- UNOPS
- USAID (USA)
- WFP
- World Bank

14. TERMINOLOGY

Abney Level - Small hand held slope measuring and levelling equipment.
Aggregate - Hard mineral elements of construction material mixtures, for example: sand, gravel, crushed rock.
Aggregate Brooming - Using a broom to spread chippings on a surface.
Alligator Cracks - See Crazing.
Apron - The flat invert of the culvert inlet or outlet.
Asphalt - Another word for bitumen. Sometimes used to describe plant mixed bituminous materials.
Asphaltic Concrete - A high quality manufactured mixture of bitumen and aggregates. Expensive and usually only used on main roads.
Attendant or Lengthman - A person contracted or appointed to maintain a section of road. Can be male or female and the term 'Attendant' or 'Lengthman' assumes either sex.
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.
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.
Black Cotton Soil - An expansive clay found widely in the North East of the country that expands and looses most of its strength when wetted
Bleeding - Defect: Excess binder on the surface of the pavement.
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.
Block Cracking - Defect: Interconnected cracks forming a series of large blocks usually with sharp corners or angles.

Brick (clay) - A hard durable block of material formed from burning (firing) clay at high temperature.
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, or may be an arch.
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 (superelevation).
Camber Board - Apparatus for checking the crossfall of the road camber, or the shoulder.
Cape Seal - A road surface layer formed by slurry seal laid on top of a bituminous chip seal.
Carriageway - The road pavement or bridge deck surface on which vehicles travel.
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.
Catchwater Drain - See Cutoff.
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.
Chippings - Clean, strong, durable pieces of stone made by crushing or napping rock. The chippings are usually screened to obtain material in a small size range.
Chip Seal - A surface layer formed by stone chippings laid onto a bituminous seal coat.
Chute - An inclined pipe, drain or channel constructed in or on a slope.
Cobble Stone (Dressed stone) - Cubic pieces of stone larger than setts, usually shaped by hand and built into a road surface layer or surface protection.

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.
Compaction - Reduction in bulk of fill or other material by rolling or tamping.
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.
Cracking - Defect: Narrow breaks in a surfacing or pavement material caused by overloading, fatigue or weakness of the material.
Crazing (Alligator Cracks) - Defect: Interconnecting network of cracks in the road surfacing.
Cribwork - Timber or reinforced concrete beams laid in an interlocking grid, and filled with soil to form a retaining wall.
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.
Deck - The part of a bridge that spans between abutments or pier supports, and carries the road traffic.
Depression - Defect: Localised low areas of limited size in the pavement surface or in any other surface.
Ditch (Drain) - A long narrow excavation designed or intended to collect and drain off surface water.
Drag - An apparatus towed behind a vehicle or piece of equipment to remove minor irregularities and redistribute loose surface material.
Drainage - Interception and removal of ground water and surface water by artificial or natural means.
Drainage Pipe - An underground pipe to carry water.
Dressed Stone - See Cobble Stone.
Drift or Ford - A stream or river crossing at bed level over which the stream or river water can flow.
Earth Road - See ENS.

Edge Cracking - Defect: Longitudinal cracking near the edge of the pavement.
Embankment - Constructed earthworks below the pavement raising the road above the surrounding natural ground level.
ENS (Engineered Natural Surface) - An earth road built from the soil in place at the road location, and provided with a camber and drainage system
Excess Aggregate - Defect: Aggregate particles not coated with binder after application of binder.
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.
Fog Seal - A very light film of binder sprayed onto a road to bind or enrich the surface.
Ford - See Drift
Formation - The shaped surface of the earthworks, or subgrade, before constructing the pavement layers.
Fretting - Defect: The loss of chippings from the surface seal or premix layer due to poor bond between the aggregate and the seal or binder.
Gabion - Stone-filled wire or steel mesh cage. Gabions are often used as retaining walls or river bank scour protection structures.
Glazing - Defect: Wear or embedment of chippings in the surfacing giving a smooth, shiny appearance.
Hand Packed Stone - A layer of large, angular broken stones laid by hand with smaller stones or gravel rammed into the spaces between stones to form a road surface layer.
Incremental paving - Road surface comprising small blocks such as shaped stone (setts) or bricks, jointed with sand or mortar.
Invert - The lowest point of the internal cross-section of a ditch or culvert.
Layby - An area adjacent to the road for the temporary parking of vehicles.
Lengthman - See Attendant.
Loss of Surface Aggregate - Defect: Removal of aggregate from a surface dressing, or from surfacings with coated aggregate, or concrete.
Macadam - A mixture of broken or crushed stone of various sizes (usually less than 3cm) laid to form a road surface layer.
Manhole - Accessible pit with a cover forming part of the drainage system

and permitting inspection and maintenance of underground drainage pipes.
Margins - The right of way or land area maintained or owned by the road authority.
Mitre Drain (Turn Out Drain) - leads water away from the Side Drains to the adjoining land.
Occasional Maintenance - Operations that are occasionally required on a section of road after a period of a number of years. Sometimes referred to as Periodic Maintenance.
Ottaseal - A surface layer formed by rolling natural gravel into a soft bituminous seal coat.
Outfall - Discharge end of a ditch or culvert.
Parapet - The protective edge, barrier, wall or railing at the edge of a bridge deck.
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.
Pavé - See Sett
Paved Road - For the purpose of this booklet, a paved road is a road with a Stone, Bituminous, Brick or Concrete surfacing.
Pavement - The constructed layers of the road on which the vehicles travel.
Permeable Soils - Soils through which water will drain easily e.g. sandy soils. Clays are generally impermeable except when cracked or fissured (e.g. 'Black Cotton' soil in dry weather).
Plumbing - Using a calibrated line, with a weight attached to the bottom, to measure the depth of water (e.g. for checking erosion by a structure).
Profile - An adjustable board attached to a ranging rod for setting out.
Ravelling - See Stripping.
Regular 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 un-skilled or trained manpower. Sometimes referred to as Routine Maintenance.
Reinforced Concrete - A mixture of coarse and fine stone aggregate bound with cement and water and reinforced with steel roads for added strength.

Riprap - Stones, usually between 5 to 50 kg, used to protect the banks or bed of a river or watercourse from scour.
Road Base and Subbase - Pavement courses between surfacing and subgrade.
Road Maintenance - Suitable regular and occasional 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.
Roadway - The portion within the road margins, including shoulders, for vehicular use.
Sanding - Spreading course sand onto a bituminous road surface that is bleeding.
Sand Seal - A surface layer formed by sand laid onto a bituminous seal coat.
Scarifying - The systematic disruption and loosening of the top of a road or layer surface by mechanical or other means.
Scour - Defect: Erosion of a channel bed area by water in motion, producing a deepening or widening of the channel.
Scour Checks - Small checks in a ditch or drain to reduce water velocity and reduce the possibility of erosion.
Scuppers - Drainage pipes or outlets in a bridge deck.
Sett (Pavé) - A small piece of hard stone trimmed by hand to a size of about 10cm cube used as a paving unit.
Shoulder - Paved or unpaved part of the roadway 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.
Slip - Defect: Slope material sliding downhill because of instability, water penetration or flow.
Slope - A natural or artificially constructed soil surface at an angle to the horizontal.
Slot - A sample cross section of the road or drain constructed as a guide for following earthworks or reshaping.
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.

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

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

Special Maintenance - Certain serious, unforeseen situations necessitating remedial action to be taken as soon as possible, e.g. flood damage, major slips. Consult the regional authorities regarding these.

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.

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

Stringer - Longitudinal beam in a bridge deck or structure.

Stripping (Ravelling) - Defect: The loss of surface seal from the pavement due to poor bond between the seal and the lower pavement layer.

Subbase -See Road Base.

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

Sub-Soil Drainage - See Underdrainage.

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

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

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

Tar Binder - A binder made from processing coal.

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

Traffic Lane - The portion of the carriageway usually 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.
Traveller - A rod or pole of fixed length (e.g. 1 metre) used for sighting between profile boards for setting out levels and grades.
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.
Turn Out Drain - See Mitre Drain.
Underdrainage (Sub-Soil Drainage) - System of pervious pipes or free draining material, designed to collect and carry water in the ground.
Unpaved Road - For the purpose of this booklet an unpaved road is a road with a soil or gravel surface.
Vented Drift - See Causeway.
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.
Windrow - A ridge of material formed by the spillage from the end of the machine blade or continuous heap of material formed by labour.
Wingwall - Retaining wall at a bridge abutment to retain and protect the embankment fill behind the abutment.
2WD - Two Wheel Drive vehicle or equipment.
4WD - Four Wheel Drive vehicle or equipment.