ROAD AND DRAINAGE MAINTENANCE

Service Delivery Training Module 3 of 4
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Service Delivery Training Module 3 of 4

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## CONTENTS

### Preface

### Introduction

### Session 1: Sustainable Road Maintenance Management

1.1 Why Maintenance of Roads is Required

1.2 Management Tasks

1.3 Classification of Maintenance

1.4 Organization and Responsibilities

1.5 Storing and Handling Materials

1.6 Allocation of Resources: Personnel, Plant Equipment and Tools in Road Maintenance

1.7 Road Inventory

1.8 Inspection and Assessment of Road Condition

1.9 Prioritization of Work and Spot Improvement

1.10 Method of Undertaking Maintenance Work

1.11 Safety Measures and Traffic Control

### Session 2: Effective Road Maintenance Techniques

2.1 General

### Session 3: Maintenance of Road Drainage

3.1 General

3.2 Objectives of Road Drainage and the Maintenance Task

3.3 Drainage of Road Surface

3.4 Maintenance Methods – Roadside Areas

### Session 4: Maintenance of Unpaved Roads

4.1 Grading / Dragging

4.2 Labour-Based Reshaping

4.3 Patching

4.4 Re-Gravelling (Labour and Tractors)

4.5 Dragging (Improvised Substitute for Mechanized Grading)

### Session 5: Maintenance of Paved Roads

5.1 General Repairs

5.2 Techniques

5.3 Resources for General Repair

5.4 Maintenance Methods

5.5 Surface Dressings Mechanized

5.6 Maintenance Methods
PREFACE

The Asia Foundation (TAF) implemented the Transparent Accountable Local Governance (TALG) Program with financial support from the United States Agency for International Development (USAID) from January 2005 - September 2007. The Foundation’s main counterparts were the Ministry of Local Government and Provincial Councils and the Sri Lanka Institute of Local Governance. The International City/County Management Association (ICMA) and Environmental Management Lanka (EML) provided additional technical assistance and support.

The TALG Program developed a number of training modules and publications as part of its institutional strengthening programme for Local Authorities (LAs) in Sri Lanka. Each of the TALG training modules was used to train officials in thirty-five LAs in Southern, Eastern, Central, North Western, North Central and Uva provinces. These were very successful in promoting effective, transparent and accountable local governance. Preparing the training modules was a painstaking process and support from the Australian Agency for International Development (AusAID) enabled The Asia Foundation to complete and publish this and the other publications in the series.
INTRODUCTION

Through the interventions made by the Foundation for the betterment of the Local Governance system in Sri Lanka, publications were developed in the following areas:

- Citizen Participation
- Local Planning
- Service Delivery
- Financial Management
- Policy and Regulations

These publications range from one-page documents of Leading Practices to Training Modules. Major categories of the publications are:

- Training Modules
- Guidebooks
- Reports and Documents
- Video Films
- Computer Applications

TALG developed many training modules mainly in the areas of Financial Management and Service Delivery. Road and Drainage Maintenance is Module 3 under Service Delivery Training. Other training modules in the series include:

- Module 1: Solid Waste Collection and Transport
- Module 2: Solid Waste Reduction
- Module 4: Solid Waste Planning and Disposal

In addition to these training modules, TALG developed video films showing successful solid waste management (SWM) initiatives implemented by the Sri Lankan and regional LAs.

Users should note that there are a range of TALG publications including Technology of Participation and Resource Directory for Local Authorities that can be used by LAs to create an enabling environment for improved road and drainage maintenance.

About this Training Module

Module 3: Road and Drainage Maintenance

In Sri Lanka, National and Provincial road authorities are responsible for the maintenance of main roads, whereas minor roads which are mainly gravel roads, are part of the LA’s area of responsibility. In addition to SWM, LAs spend a considerable amount of money on the maintenance of roads and drainage facilities. LAs are only able to maintain a fraction of minor roads due to lack of resources and ‘know how’. This module targets low cost but effective maintenance practices, and management procedures to ensure better roads and drainage maintenance.
What is Inside this Module

The publications developed by TALG can be used by different users, ranging from beginners to practitioners, those working in LAs and for those working as partners of LAs. This publication contains all of the resources developed for the delivery of a two-day workshop in Road and Drainage Maintenance.

This training module provides comprehensive and detailed learning materials on Road and Drainage Maintenance and although it is specifically intended for Technical Officers and others engaged in road and drainage maintenance at supervisory level, it can be used as reference material for all practitioners in LAs and as background information for trainers. This module provides practical guidance for: (1) sustainable road maintenance management and (2) effective road and drainage maintenance techniques on all road components under the LA responsibility. The attention of the module is primarily focused on the use of direct labour or small-scale labour contractors for the execution of maintenance operations. Although most of the local bodies possess little or no basic machinery and equipment like rollers, motor graders, water browsers etc, the use of this equipment is also covered in this module since their use is growing and may expand in the future.

Attached to this module is a CD, which provides a ‘PowerPoint’ version of the learning materials with a focus on the needs of LAs. Additional resources include Visual Condition Assessment Standards to carry out assessment of conditions of roads and stormwater facilities and interactive lesson activities. Also included is a performance monitoring tool for developing a road inventory, which is an ‘MS Excel’ spreadsheet application developed to help LAs in maintaining road and drainage facilities.

The Main Objectives of this Module

- To provide guidance to LAs in Sri Lanka and officials who engage in Road and Drainage Maintenance activities.
- To provide knowledge, skills and tools for planning LA Road and Drainage Maintenance activities in a systematic manner.
- To assist LAs to deliver efficient and effective Road and Drainage Maintenance, and to monitor and manage the workforce engaged in these activities.
- To assist LAs to ensure satisfactory levels of Road and Drainage Maintenance activities are implemented that meet the needs and demands of citizens.

How to Use this Module

The resources in this publication may be used:

- To enhance knowledge in this specific topic.
- To share the knowledge with others.
- To support a training programme and awareness campaigns.
- To improve the existing system and enhance performance monitoring.

Trainers and beginners can use these learning materials to obtain knowledge on leading practices and issues of Road and Drainage Maintenance in LAs. Learning materials will provide guidance to decision-makers and staff who are involved in Road and Drainage Maintenance activities.

Trainers can use the prepared ‘PowerPoint’ presentations to conduct awareness programmes for LA staff, decision-makers and other interested individuals. Group exercises can be used to provide better practical knowledge on Road and Drainage Maintenance.
SESSION 1: SUSTAINABLE ROAD MAINTENANCE MANAGEMENT

1.1 Why Maintenance of Roads is Required

Sri Lanka possesses an extensive road network of about 100,000km of classified roads and unclassified roads. The roads under the jurisdiction of the Road Development Authority and the Provincial Councils are categorized as classified roads while the roads under the jurisdiction of the Municipal Councils (MCs), Urban Councils (UCs), Pradeshiya Sabhas (PSs) and other institutions are categorized as unclassified roads. The unclassified roads account for approximately 75,000km and provide accessibility to the bulk of the population, mainly in the rural areas.

Improved road transport facilities are essential for the economic development and social activities of a nation. The deterioration of a country's transport facilities is a clear indication of the decline of economic growth, which is obviously very undesirable. One of the essential activities required for ensuring that the costly investment in road infrastructure is maximized, is effective maintenance. It should also be kept in mind that neglected or delayed maintenance causes expensive re-constructions and rehabilitation requirements, affecting all sectors of the economy. In addition, effective and timely maintenance will reduce vehicle operating cost, improve road safety and ensure transport punctuality. Therefore, effective and efficient maintenance is required to:

- Reduce the rate of deterioration (to prolong the life of the facility).
- Lower vehicle operating costs of the users by providing a good running surface.
- Enable greater regularity, punctuality and safety.

1.2 Management Tasks

The Officer in charge of maintenance has the responsibility of programming the activities of maintenance work throughout his/her area, with an appropriate allocation of resources provided by the authority concerned. This responsibility involves a sequence of tasks, which can be summarized as follows:

(i) Inventory: recording the basic characteristics and components of each section of the road network.
(ii) Inspection: examining the road and measuring its condition.
(iii) Determination of maintenance requirements: analyzing why defects are occurring and deciding what maintenance activities are needed to correct them so as to delay further deterioration.
(iv) Resource estimation: costing the activities of the maintenance programme in order to determine the overall budget.
(v) Identification of priorities: deciding the work that has to take priority.
(vi) Monitoring: checking the quality and effectiveness of the work.

Unpaved roads deteriorate more rapidly than paved roads and require more frequent attention. Therefore maintenance activities should be carried out at regular and predetermined intervals throughout the year, without deferring action.

1.3 Classification of Maintenance

Road maintenance activities can be classified based on the nature of each activity and the frequency at which they should be carried out.
a. Routine Maintenance
b. Recurrent Maintenance
c. Periodic Maintenance
d. Urgent Maintenance

**Routine Maintenance**
This is required for the general upkeep of the road. Items covered are:
1. The general upkeep of the shoulder and the roadside, weeding, jungle clearing, filling eroded areas.
2. Clearing drains and culverts, manholes etc.
3. Cutting scupper drains.
4. Cleaning and painting road furniture and structures.

**Recurrent Maintenance**
These activities may be required at intervals throughout the year depending on the damaging effects of traffic, rain etc.
They include:
1. Repairing potholes, ruts, depressions, cracks etc.
2. Corrections to the edges of pavements and shoulders.

**Periodic Maintenance**
These are required at periods of several years of frequency depending on the damaging factor as well as the standard of maintenance.
They include:
1. Base and surface correction, surface application.
2. Grading and levelling of shoulders.

**Urgent Maintenance**
Urgent maintenance covers the items to be carried out without delay to avoid danger to the traffic.
They include:
1. Restoration of flood damage, slides etc.
2. Road diversions.
3. Removal of fallen trees and branches.

**1.4 Organization and Responsibilities**
There are many opportunities for the Maintenance Officer to apply his/her skills; to improve management methods, planning, work scheduling and especially to show a personal commitment to maintenance work by regularly inspecting the roads and making staff aware of his/her interest, which is a prime contributory factor for enhancing effective and efficient road maintenance.
The Maintenance Officer should take every possible opportunity to go out of the office and be on the road. Many of the
existing maintenance problems could be overcome by this simple act, which infers one's dedication and commitment. The Officer will have a good opportunity to ascertain a thorough knowledge of the road network under his/her charge and also to recognise areas of distress. Priorities can then be assessed much more easily and first-hand knowledge acquired of the maintenance activities that have actually been carried out. The Officer can also see the quality of maintenance work carried out and use his/her professional skills and expertise to advise the subordinates on problems in the field as they arise. The fact that the Officer spearheading the maintenance team is frequently on the road would enhance the enthusiasm of co-workers and contribute to motivate the maintenance crew and eventually lead to improvement of both quality and quantity of work. Above all, what influences the standard of road maintenance is the attitude of the Officer who is responsible for maintenance.

1.5 Storing and Handling Materials

Proper storing and handling of materials are very important as:

1. Improper handling and storing affects the quality.
2. Proper storing will keep a check on quantity, avoid pilferage, misuse and contamination.

1.6 Allocation of Resources: Personnel, Plant Equipment and Tools in Road Maintenance

Success of maintenance activities depends mostly on the way the Officer in charge handles them and the most difficult task is handling personnel. This requires special skills.

Maintenance Gang
When direct labour is used for maintenance, the following general requirements for personnel, vehicles and equipment may be used as a guide. The actual requirements should be adjusted according to the job requirements.

Personnel
1. Gang Leader
2. Driver
3. Several labourers (depending on the work)

Vehicles, Tools and Equipment
1. One small truck or tractor and trailer.
2. One handheld vibrating roller or hand drawn roller plus a plank to help load onto the truck.
3. One hand rammer for each labourer, used on compaction.
4. One pickaxe for every two labourers.
5. One broom for every two labourers.
6. One shovel or mammoty for every two labourers.
7. One extension rod for culvert clearing for every two labourers.
8. One rake for every two labourers.
9. One 200 litre barrel of water.
10. One bucket or watering can.
11. One axe.
12. Safety equipment: danger board, traffic diversion board, safety jackets etc.
13. One or two wheelbarrows for a gang.

1.7 Road Inventory

Content and Preparation

The inventory is an organized set of information about the basic engineering and traffic characteristics of the road network. It records the main features of each section of road and indicates the level of traffic use. This information is an essential reference source for the subsequent stages of inspection and analysis needed to set priorities.

The content of the inventory should be directly relevant to maintenance management. When it is first drawn up, it should be as simple as possible and may only contain information on the following items:

- Type of surface and construction: carriageway and shoulders.
- Cross-section width: carriageway and shoulders.
- Traffic volume: annual average daily traffic (numbers of vehicles per day).

As the inventory is built up, information on the following items can be added:

- Structures: location and size of pipe culverts, box culverts and bridges.
- Junctions: location.
- Road furniture: road signs, road markings, guardrails etc.

Presentation

There are two useful ways of presenting the information recorded in the inventory:

- Diagrammatic Maps.
- Strip Maps (Fig: 1).

There are a simple drawings, which provide information about a section of road and its surroundings. Its main use in the field is provision of a quick means of reference during inspections and surveys. It is often convenient to keep these maps together in a folder.
1.8 Inspection and Assessment of Road Condition

**Inspection**

Regular inspections are carried out to: identify locations where deterioration is occurring; measure the extent of the problem and determine the actions required.

**Frequency of Inspection**

The Maintenance Officer should inspect the roads as much as practicable. A wet day inspection will be particularly useful in detecting cracking in bituminous surfaces (since this defect is more easily visible when the road surface is drying after rain) and in assessing the efficiency of drainage.

**Condition Assessment Surveys**

In assessing the condition of the road, it is recommended to use simple equipment to measure and record the routine and recurrent maintenance needs.
Road Condition Assessment

Name of the Road: .................................................................
Division: ...........................................................................
Length: ...........................................................
Date: ..............................................................................
Assessment Code / 500 m

<table>
<thead>
<tr>
<th>Grading</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>L = Close to Standard</td>
<td>3 = Close to Standard</td>
</tr>
<tr>
<td>M = Medium (Substandard)</td>
<td>Or 2 = Substandard</td>
</tr>
<tr>
<td>H = High (Need Urgent Attention)</td>
<td>1 = Need Urgent Attention</td>
</tr>
</tbody>
</table>

Name of the Officer: ..................................................................

<table>
<thead>
<tr>
<th>Section Km</th>
<th>Cracking</th>
<th>Potholes</th>
<th>Edge break left</th>
<th>Edge break right</th>
<th>Shoulder left</th>
<th>Shoulder right</th>
<th>Drainage left</th>
<th>Drainage right</th>
<th>Vegetation left</th>
<th>Vegetation right</th>
<th>Total (if rating is used)</th>
</tr>
</thead>
<tbody>
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<td>0.0 to 0.5</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 to 1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0 to 1.5</td>
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</tr>
</tbody>
</table>

Fig: 2
Recording Results

Fig: 2 shows how standard pre-printed forms can be used to record the results of inspection surveys. Pre-printed forms are especially useful in providing a checklist during an inspection, and so reduce the possibility that significant information may be omitted. It may, however, be useful to summarize key results in the form of statistical tables.

The Grading L, M and H can be given values (The Rating) as 3,2 and 1 respectively. Adding the values in a row will determine the relative extend of damage in a section, while the sum of values in a column indicates relative condition of the road in respect to a maintenance item of a particular road length.

1.9 Prioritization of Work and Spot Improvement

If the Maintenance Officer is fortunate enough, all the resources required to carry out the necessary work will be available. However, it is more likely that resources will be scarce and a decision will have to be made on the most effective way of utilizing them. Therefore, it is essential to work out priorities objectively and consistently.

The method here is simply based on the importance of the road and effect of the maintenance activity on traffic. It has two basic questions:

(i) How critical is a particular maintenance activity to traffic performance?
(ii) How significant is the particular road as a transport link?

Maintenance Activities by Order of Importance

Maintenance activities may be ranked in the following order of importance:

- Urgent.
- Routine drainage work.
- Recurrent work.
- Periodic work.
- Other routine work.
- Special.
- Overlaying.
- Reconstruction.

1.10 Method of Undertaking Maintenance Work

Labour and Equipment

Most maintenance operations need to allow for the application of labour-based methods. Table: 1 compares the equipment and labour-based methods in different maintenance operations.

In choosing between equipment-based and labour-based methods, consideration should be given to the required standard of work achieved by each method as well as costs. However, regardless of the above, if equipment is not available, only the labour-based method can be used.
Focus on Labour-Based and Equipment-Based Methods

<table>
<thead>
<tr>
<th>Activity</th>
<th>Labour</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain cleaning and cutting.</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Cleaning and minor repairs to culverts and bridges.</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Scour controls.</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Repair of structures.</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Grading unpaved surfaces.</td>
<td>Impossible</td>
<td>Good</td>
</tr>
<tr>
<td>Patching sanding or local sealing of bituminous surfaces.</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Filling on unpaved surfaces and slopes.</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Grass cutting.</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Manufacturing signs.</td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>Repairing and replacing traffic signs.</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Road line markings.</td>
<td>Fair</td>
<td>Good</td>
</tr>
</tbody>
</table>

Table: 1

Note
(i) It is necessary to check carefully that labour will be available in the actual place of work.
(ii) Standardized tools of good quality are vital in order to achieve high levels of output.
(iii) Arrangements may need to be made to transport labour to and from the work sites. For large labour forces, this can be a substantial task.

Direct Labour and Contract
Road maintenance organisations usually carry out much of their work by direct labour. However, small local contractors can carry out some maintenance activities. The use of contractors can reduce the burden on scarce government staff and also bring lower costs as a result of competitive pressures on efficiency. However, contract work does require the preparation of detailed contract documents and a high degree of supervision and inspection.

The following activities present no serious problems in the control of quality or quantity if carried out by contract:

a) Supply of Materials
   • Natural gravel
   • Rock aggregate
   • Sand
   • Precast concrete blocks
   • Precast concrete culvert rings
b) Maintenance Operations

- Excavation of side drains
- Construction of culverts
- Re-gravelling
- Surface dressing
- Grass-cutting
- Supply of equipment and vehicles

1.11 Safety Measures and Traffic Control

Fig 3
Principles

When work is being carried out on or close to the carriageway, it is the Maintenance Officer’s responsibility to see that adequate measures are taken to warn and protect road users and maintenance workers. The Maintenance Officer should instruct all supervisors in safety measures, including traffic control, and the use of temporary road signs.

In selecting and positioning temporary road signs, the following principles should be applied.

i. Only standard signs should be used.

ii. The signs must be clean and in good condition.

iii. The standard signs should be displayed in a standard layout.

iv. The layout used must give drivers time to understand and respond to the information, which the signs convey.

Recommended standard signs are shown in Fig: 3

It may not be possible for the Officer to obtain the necessary signs from Departmental stores. Each road maintenance gang should be provided with signs appropriate to the work it is carrying out and all supervisors should be trained in their use and layout. All temporary signs must be removed as soon as the work they relate to is complete. If they are not, the value of the sign will be reduced.

From the point of view of safety and traffic control, road maintenance work may be divided into four categories:

i. Work which does not affect the travelway, such as cleaning outside drains and cutting grass on shoulders.

ii. Work requiring partial closure of the travelway, such as repair work to surface or base which is restricted to one lane while traffic continues to use the other lane.

iii. Work on the centre line, such as white line painting.

iv. Work requiring total closure of the road, with construction of a temporary diversion, such as the reconstruction of a damaged culvert.

Whenever possible during maintenance work, the supervisor and the entire workforce should wear yellow or orange safety vests. Similarly, whenever possible all vehicles and equipment should be painted yellow or orange and should carry red and white striped marker boards front and rear. All vehicles and equipment should work with headlights switched on and, where possible, should carry yellow flashing warning lights. If warning lights are not available, vehicles and equipment should carry a yellow or orange flag.

Edge working
Where roadwork is being carried out which does not affect the travelway, or where work such as grading or dragging is being carried out on the area beyond the carriageway, the sign layout shown in Fig: 4 is recommended. Warning signs should be placed before work starts and must be placed in the following order:

1. ‘Men Working’ signs should be placed at the approaches to the work area.
2. ‘Road Clear’ signs should be placed at the ends of the work area.

When the work has been completed, signs should be removed in reverse order. Signs must not be left on the road or at the roadside overnight. They should be removed and returned to the depot.

**Lane Closure**

![Diagram](image)

Fig: 5

For repairs to the carriageway such as patching which requires closure of one lane, the sign layout shown in Fig: 5 is recommended. Before work starts, warning signs, barriers and cones must be placed around the work area. Work will be carried out on one side of the road at a time allowing traffic to pass on the other. Signs must be placed in the following order:

1. ‘Men Working’ signs should be placed 200 metres in front of the work area.
2. ‘Road Narrows’ signs should be placed 100 metres in front of the work area.
3. ‘Keep Left/Right’ arrows should be placed at the start of the work area.
4. Barriers should be placed at each end of the work area.
5. ‘Keep Left/Right’ arrows should be placed next to the barriers.
6. Cones should be placed in a taper at the approaches to the work area and at a spacing of 10 metres along the middle of the road next to the work area.
7. ‘Road Clear’ signs should be placed 200 metres beyond the work area.
Traffic Controllers should stand opposite the barriers on the other side of the road holding reversible ‘Stop/Go’ signs. The Supervisor as the leader should appoint one Controller. He should decide when to change the direction of the signs and the other controllers should follow his lead. In this way, the Controllers work closely together to ensure that only traffic from one direction is allowed to pass at a time. When the work area is short, only one Traffic Controller may be needed. The Maintenance Officer should train these men in the use of the signs and only the trained men should be allowed to operate them. Police assistance in training may be helpful.

On low-traffic roads, the Maintenance Officer may approve the use of a simpler system of traffic control.

Patching work should not be left unfinished overnight but if this sign layout is being used for repairs to a culvert or a washout, then at night the approaches must be adequately lit. Kerosene lanterns may be adequate on lightly trafficked roads or where speeds are low, but high-intensity lamps should, if possible, be used on heavily trafficked roads. A watchman should always be in attendance to ensure that the lamps are working and are not interfered with or stolen. Lamps should show a yellow light. Flashing lamps are best as they consume less power and are more easily seen.

When the work has been completed, signs should be removed in reverse order.

**Centre Line Working**

When painting centre line marking on the road, considerable care must be taken and it is most important to pay a great deal of attention to safety measures. The sign layout shown in Fig: 6 is recommended.

Before work starts, warning signs, barriers and cones must be placed around the work area. They must be placed in the following order:
1. ‘Men Working’ signs should be placed 200 metres in front of the work area at the side of the road.
2. ‘Road Narrow’ signs should be placed 100 metres in front of the work area at the side of the road.
3. ‘Keep Left’ arrows should be placed in the centre of the road at the start of the work area.
4. Barriers should be placed behind the ‘Keep Left’ signs.
5. Cones should be placed at a spacing of 10 metres on either side of the work area.
6. ‘Road Clear’ signs should be placed 200 metres beyond the ends of the work area at the side of the road.

When the work has been completed, signs should be removed in reverse order. Signs must not be left on the road or at the roadside overnight. They should be removed and returned to the depot.

**Diversions**

A diversion will enable maintenance work to be carried out more efficiently and more safely. In particular, diversions are needed for re-gravelling work and major culvert repairs. If traffic is to be diverted for more than one or two days, or the work is being carried out during the wet season, the diversion should be constructed with an adequate base and surfaced with gravel. A small gang should be allocated to keep the diversion in good condition. Diversion should be wide enough to allow two lorries to pass.

After the diversion has been completed and before the maintenance work starts, warning signs, barriers and cones must be placed around the work area. The layout shown in Fig: 7 is recommended. Signs must be placed in the following order:

1. ‘Men Working’ signs should be placed 200 metres in front of the work area.
2. ‘Turn Left/Right Ahead’ arrows should be placed 100 metres in front of the work area.
3. Cones should be placed diagonally across the road to lead into the diversion.
4. ‘Keep Left/Right’ arrows should be placed at both ends of the lines of cones.
5. Barriers should be placed behind the lines of cones.
6. ‘Road Clear’ signs should be placed 200 metres beyond the ends of the diversion.

Diversions will usually be in operation at night as well as by day and the approaches must be adequately lit. Kerosene lanterns may be adequate on lightly trafficked roads or where speeds are low, but high-intensity lamps should if possible be used on heavily trafficked roads. A watchman should always be in attendance to ensure that the lamps are working and are not interfered with or stolen. Lamps should show a yellow light. Flashing lamps are best as they consume less power and are more easily seen.

When the work has been completed, signs should be removed in reverse order.

**Development of Safety Measures**

In many developing countries, no safety measures are provided at all during maintenance work. The Maintenance Officer must understand that the safety of workers and that of the road user during maintenance operations is his/her responsibility. Staff must be trained in methods of signing and traffic control and should understand the need for safe working.

Initially, it will probably not be possible to provide all the safety equipment recommended here. However, simple signs can be easy and cheap to make and it is possible to improvise cones and barriers. Tufts of grass cut from the roadside can be used instead of cones and effective road markers can be made from old oil drums painted with black and white bands and filled with sand, stones or water. If signs cannot be provided, a maintenance vehicle should be parked on the road between the on-coming traffic and the maintenance workers with its lights switched on.

When traffic volumes are very low, workers may relax these standards. In particular, it may not be necessary to use ‘Stop/Go’ signs. However, by relaxing standards, road users and maintenance workers must not be placed in a hazardous position.
SESSION 2: EFFECTIVE ROAD MAINTENANCE TECHNIQUES

2.1 General
The maintenance aspects and items that are common to both paved roads and unpaved roads are discussed in this chapter.

Maintenance of Road Furniture
Traffic signs, markings and other furniture are the means of conveying information about the road to all road users, motorists and pedestrians as well.
They warn, instruct, direct and guide the users. As such, their installation and maintenance should be given the highest possible care.

Location and Erection of Signs
Road signs are erected in such a way that the driver has adequate time to read the message and to take action accordingly. The sign must fall within the driver’s cone of vision. He should not have to turn his head to see the message. The background of the sign should make the sign conspicuous.

Maintenance of Signs
In the maintenance of signs the following should be attended to:
(i) Cleaning of signs.
(ii) Repainting components of sign assembly.
(iii) Realigning badly oriented/tilted posts.
(iv) Improving visibility of signs.

Markings
Pavement markings are normally made with one or more of the following:
• Paint, with or without glass beads, embedded or premixed.
• Thermoplastics, with or without reflective properties.
• Reflective road studs and other raised pavement markers, embedded in the road.

Other Road Furniture
Other common road furniture considered in this document are Guard Rails and Walls; Guide Posts and Guard Stones.
SESSION 3: MAINTENANCE OF ROAD DRAINAGE

3.1 General

Drainage is the most important aspect that determines the performance of a road. Failure of roads is often attributed to poor drainage.

“The road with good drainage is a good road” is just as valid today as it ever was.

Water, when allowed to enter the road structure has the effect of weakening the pavement layers and making them susceptible to the damaging effects of traffic. Water can enter the road structure in one of two ways; either by stormwater directly penetrating the surface or indirectly, by ground water infiltration.

Stormwater that falls on the road needs to be led away in a controlled manner. If allowed to flow too fast it will cause erosion of the edges, drains and the embankment slopes; and if allowed to float too slowly it will cause siltation in drains and culverts. If allowed to stagnate, the water will penetrate into the structure, through surface cracks etc., and also from the sides.

In flat terrain, special efforts have to be made to obtain sufficient gradients for the side drains and also to find suitable outlets for them, such as natural streams. In some cases, lead-away drains can be used to convey water away from the road. Also, the drains may have to be made as broad and as deep as possible so that they become temporary catchments, providing the necessary extra time for the stormwater to get away from the roadway area.

In hilly and mountainous terrain, efforts will always have to be made to reduce the flow velocities in the drains and in the outlets (Fig: 8).

The best preventive maintenance for roads is to maintain road drainage. This makes the road last longer.

DRAINAGE FEATURES

Fig: 8
3.2 Objectives of Road Drainage and the Maintenance Task

The objectives of road drainage can be broadly classified as:

- Prevention of accumulated surface water on or by the roadway and flowing onto the roadway.
- Interception of ground water from entering the road structure from beneath.
- Prevention of erosion of the roadway edges, drains, embankment slopes, cut slopes and the roadside itself.
- Conveying river and stream water across the roadway in an appropriate manner.

The objective of road drainage maintenance is to ensure that its route is free from obstruction and to retain the cross-section and the gradient. They must function properly so that surface water and ground water can drain freely and quickly away from the road.

“Water is the worst enemy” of any road.

It can:

1. Erode soil.
2. Weaken pavement.
3. Destroy shoulders and slopes.
4. Wash out culverts and embankments.

Regular site inspections, particularly during the rainy season will be an essential tool to clearly identify the problems.

3.3 Drainage of Road Surface

Drainage of road surface is affected by the following aspects:

- Cross-falls
- Surface conditions
- Shoulder level
- Scupper drains

Cross-Fall

Road surface should be constructed and maintained with sufficient cross-fall to shed the stormwater to the edges and into the side drains. For this purpose the following cross-falls are normally adopted.

- Paved roads: 2 to 3 per cent
- Earth and gravel roads: 4 to 6 per cent
- Shoulders: Desirable maximum of 6 per cent

Normally, the shoulder should possess a greater cross-fall than the road.

The cross-fall percentage is calculated by dividing the height of the fall by the length of the base, as shown below.
Cross-fall (percentage) = \(\frac{AB}{BC} \times 100\)

Eg: If AB is 15 cm and BC is 3.0 m (300 cm) the cross fall is 5%
\[
\frac{15 \times 100}{300} = 5\%
\]

**Surface Conditions**

Surfaces of roads should always be devoid of potholes, ruts, depressions and cracks as far as practicable, as these will allow water to penetrate into the road structure and cause damage.

**Shoulder Level**

It is a common occurrence that the edges of paved roads are eroded due to the action of water. This is particularly so where the water tends to run along the road as a result of road gradients being relatively high or as a result of insufficient cross-fall, with water being unable to crossover as indicated in Fig: 9.

A shoulder being higher than the carriageway is a common occurrence with most of our roads. Reducing such high shoulders is costly so finding alternative ways of dealing with the water is important for ensuring long road life.

**Scupper Drains**

Scupper drains provide a relatively cheap means of draining across shoulders that are high. These are shallow transverse drains cut to taper from the road edge to the side drains, to average widths varying from about 0.6m to about 1.0m and to depths to suit the shoulder and the drain. They may be suitably angled to assist the flow as shown in Fig: 10. Their gradients should be kept to between 4 and 6 percent, generally. Where scupper drains lead water over embankments or hillsides, suitable drop structures will have to be constructed to ensure that such water does not cause erosion.

Scupper drains should be spaced at suitable intervals normally varying between 15 - 30m and as far as practicable, they should be positioned at the lowest point within each interval.
Another common problem in Sri Lanka is where the shoulder gets eroded from cars using the unpaved shoulder when meeting a large vehicle coming the opposite way, or when multiple vehicles are using a single lane. This causes a small depression at the edge of the road that collects water when it rains and does not allow the water to flow to the roadside ditch.

**Side Drains of Roads**

The essential function of side drains is to collect water from the roadway, to intercept outside water from flowing into the road and convey the water to a suitable outlet point. The outlet point could be lead-away drains or natural streams.
**Shape and Size of Side Drains**

Normally, the side drains should have a trapezoidal shape with side slopes not less than 1:1 and bottom widths not less than about 0.45m so that the sides are stable and self-cleaning and de-silting. The depths of these drains should be a desirable minimum of 0.6 m.

![Normal Side Drains](image)

However, where it is necessary to keep the ground water low, the depths have to be increased to over 1.0m. In restricted areas both the side slopes and the bottom widths may be reduced. However, cutting the sides vertically should normally be avoided.

The bottom and the further side of the drain should be manually shaped as shown. However, finishing the drains to a V shape should only be resorted to in places where there are space restrictions.
**Angle Drain**

![Angle Drain Diagram](image)

**Saucer Drain**

![Saucer Drain Diagram](image)

**Drainage Ditches**

In low lying areas and in restricted areas where drains cannot be continued due to obstructions such as parapet walls, electric posts etc., it is suggested to have closed end ditches (Absorption Ponds).

**Lead-Away Drain**

![Lead-Away Drain Diagram](image)
Drainage is not possible without lead-away drains. Lead-away drains are essential to take away and dispose of the water from side drains. It is very important for the engineer to check the lead-away drains regularly to avoid blocks, which will subsequently cause the failure of drainage.

The lead-away drains, particularly in the hill country, should be protected from erosion due to fast flow of stormwater. Suitable drop structures and stilling basins may have to be constructed, in this regard. Lead-away drains in lower lying areas on the other hand, have to be de-silted regularly due to the slowness of flow of stormwater in them causing deposition of silt.

**Catch Drains (Interceptor Drains)**

The function of a catch drain is to intercept surface water flowing towards a road cutting or formation embankment. It thus prevents the water flowing down the cut batter, which may cause severe scouring.

![Fig: 17 Catch Drains](image)

**Batter Drains**

In a situation where water has to be drained down an embankment slope or down a cutting batter, batter drains are constructed. Normally, the slope of the drain down the batter is too steep to allow the water to flow. As such, batter drains are generally lined with concrete or grouted stone. The batter drains may also be stepped to break the flow of water.

**Subsurface Drains/Sub Soil Drains/Under Drains**

Subsurface drains are provided to lower the water table, particularly due to the water trapped by impervious material. An under drain normally consists of perforated pipes surrounded by an aggregate fill. Pipes used may be of concrete, clay or PVC.
3.4 Maintenance Methods – Roadside Areas

Including the shoulders and side slopes, most roadside area maintenance activities can be achieved by labour, and are suitable work for a mobile or local gang, or an individual lengthman living close to the road.

1. Shoulders
   a. **Defect: Obstructions such as rocks, trees or tree branches, soil heaps and abandoned vehicles/debris.**
      
      **Main Causes**
      - Material fallen from slopes or trees, material washed onto the shoulders.
      - Debris left by road users.
      
      **If Neglected**
      - Hazard to road users.
      - Obstruction of water flow from carriageway.
      
      **Remedies**
      - Remove obstructions.

 b. **Defect: Shoulder Higher than Carriageway**

   ![Fig: 18](image)

   **Main Causes**
   - Carriageway surface material has collected on the shoulder by the action of traffic/water.
   - Soil from the cutting has slipped onto the shoulder.
   - Vegetation has trapped material on the shoulder.
   - Shoulder material has been displaced by the action of traffic.
   
   **If Neglected**
   - Surface water can pond at the edge of the carriageway and weaken the pavement and shoulder.
   - Danger of accidents.
   - Excess material may block the roadside ditch.
   
   **Remedies**
   - Reshape or re-grade shoulder surface to the correct level.
   - Vegetation control.
c. **Defect: Shoulder Lower than Carriageway**

![Fig: 19](#)

**Main Causes**
- Traffic has been travelling on the shoulder and material has been worn away.
- Water erosion of the shoulder, settlement of the shoulder, the carriageway has been overlaid leaving the shoulder surface lower than the pavement.

**If neglected**
- Inadequate support for the road pavement.
- Water collects and softens the shoulder and pavement foundation.
- The edge of the pavement will break when vehicle wheels run over it, increasing the risk of accidents.

d. **Defect: Ruts or Depressions**

**Main Causes**
- Traffic has been travelling on the shoulder and material has been worn away.
- Water erosion of the shoulder, settlement of the shoulder, the carriageway has been overlaid leaving the shoulder surface lower than the pavement.

**If neglected**
- Inadequate support for the road pavement.
- Water collects and softens the shoulder and pavement foundation.
- The edge of the pavement will break when vehicle wheels run over it, increasing the risk of accidents.

e. **Defect: High Vegetation on Shoulders**

![Fig: 20](#)

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

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

**Remedies**
- Vegetation control.

![Fig: 21](#)
2. Drains
   a. Defect: Obstructions
      Main Causes
      • Vegetation growth, bushes, fallen trees, debris, loose silt, loose rocks.
      
      If neglected
      • Blockage of ditch.
      
      Remedies
      • Clearing and cleaning.

   b. Defect: Silting
      Main Causes
      • Invert slope is too flat; the water cannot flow at sufficient speed.
      
      If neglected
      • Ditch blockage.
      
      Remedies
      • Deepen ditch (de-silting), and/or provide new turnouts.
      • Where deepening or turnouts are not possible because of topography, the construction of a new culvert with a drop-inlet may be possible, in order to discharge water onto the other side of the road.

   c. Defect: Ponding in Drains and on Shoulders
      Main Causes
      • The ditch cross-section is too small; the ditch gradient is too flat.
      
      If neglected
      • The shoulder material becomes soft and can easily erode.
      • The pavement can also be flooded and thereby weakened.
      
      Remedies
      • Deepen ditch.
      • Provide new turnout.

   d. Defect: Drain Cross-Section Destroyed (Unlined Drain)
      Main Causes
      • Vehicular or animal traffic; cave-in.
      
      If neglected
      • Partial silting will result if the ditch sides have collapsed.
      • Erosion can start where water flow passes the blocked section.
Remedies
- Reshape/re-grade ditch, line drain.

e. Defect: Invert and Sides of Drains are Eroded
Main Causes
- Invert slope is too steep.
If neglected
- The water flows at high speed and starts eroding the soil. The ditch becomes deeper (ravine). The sides then cave-in, the road shoulder and even part of the carriageway can be washed away.

Remedies
Erosion control:
- Re-grade/realign drains.
- Provide repair scour protection.
- Line drain slopes and invert.
- Construct cascade.

f. Defect: Drain Lining is Damaged
Main Causes
- Poor construction workmanship.
- Soil settlement, erosion of soil under ditch lining.
- Poor alignment or sudden change in flow direction.
If neglected
- When flowing water reaches the soil protected by the lining, erosion starts.
- The amount of soil washed away increases; the lining is further damaged by loss of support, leading to complete destruction of the lining.

Remedies
Erosion control:
- Repair lining.
- Realign drain.

g. Defect at Drain Outfall
Main Causes
- Flow too fast.
- Flow too concentrated for the soil at the outfall to resist.

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

**Remedies**

Reduce water flow and speed:
• Realign drain to flatter gradient.
• Provide new turnout drain, upstream from existing.

Reduce impact at outfall:
• Construct cascade.
• Construct flow spreader.

Erosion control for the soil:
• Turfing.
• Wattling.

3. Manholes and Drainage Pipes

a. **Defect: Water Overflowing at Manhole**

**Main Causes**
• The manhole or connected underground pipes are blocked and water cannot flow as intended.

**If neglected**
• Flooding of road shoulder or carriageway.
• Drainage system becomes ineffective.
• Danger of earth slip or weakening of the pavement.

**Remedies**
• Clear manhole and underground pipes.

b. **Defect: Manhole Cover or Grating is Missing/Damaged**

**Main Causes**
• Accident, vandalism.
If neglected
- Open manholes become a danger to people and animals. Vegetation and debris have uncontrolled access and blockage can occur.

Remedies
- Replace manhole cover or grating.

c. Defect: Manhole is Covered with Soil and Vegetation

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

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

Remedies
- Clear manhole area.

Public require education on:
- Not burning trash in drainage ways.
- Collecting leaves and other debris in drainage ways.
- Cleaning of drainage ways.

4. Maintenance of Culverts and Bridges

a. Defect: Silting or Debris Blocking

Main Causes
- Invert slope too flat.
- Culvert constructed too low, so that material from the stream bed becomes deposited in the culvert.
- Vegetation and floating debris carried by water has become lodged in the culvert.

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

**Remedies**
- Clearing and cleaning.
- If floating debris is a problem, the provision of a debris rack should be considered.

b. **Defect: Cracks**

**Main Causes**
- Settlement of soil below culvert.

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

**Remedies**
- Repair cracks.
- Reconstruct at correct level and fall.

c. **Defect: Erosion of Culvert Bed at Outlet**

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

**If neglected**
- The streambed is washed. The culvert downstream head and wingwalls and even a section of the culvert and road embankment can collapse.

**Remedies**
- Erosion repair.
- Construct outfall basin.

d. **Defect: Minor Headwall Damage**

**Main Causes**
- Minor settlement.
- Scour or erosion.

**If neglected**
- Erosion at the headwall.
- Culvert blockage or collapse.

**Remedies**
- Headwall repair.
SESSION 4: MAINTENANCE OF UNPAVED ROADS

Unpaved Road

4.1 Grading / Dragging

The task is to improve earth and gravel roads by Grading/Dragging the existing surface material. Grading is normally a ROUTINE MAINTENANCE task. It is carried out by a self-propelled grader.

Dragging can be done with the help of a dragger.

Objective

- To restore the ‘camber’ by grading the sides and shoulders towards the centre of the road.

Grading is used to correct the following defects:

Defects

- Loss of shape
- Ruts
- Potholes
- Corrugations
- Erosion gullies
- Silted or blocked ditches
Resources
Personnel, plant and tools, signs and safety equipment.
Grading is a fast moving activity.
The grading requirements depend on:
- Road condition (light or heavy grading).
- Moisture conditions.
- Compaction requirements.
- Resources available.

Personnel
The categories and numbers of personnel depend on the equipment resources used. Each grading gang should include:
- Supervisors

Plant Operators and Drivers
- 1 operator for each motor grader.
- 1 driver for each tractor.
- 1 light vehicle driver.
- 1 operator for each motorised roller.
- 1 driver for each water tanker.
Workforce

- 1 mechanic for daily servicing and minor repairs.

Plant and Tools

Motor Graders
Motor graders of 100 hp (75 kW) or more can be used for light or heavy grading.

Rollers
1 or 2 rollers, if available. Rubber tyre (Pneumatic) rollers are preferred. They can be self-propelled.

- Water
When water tankers are needed and available, the number required will depend on the distance that water has to be hauled. These should be fitted with a spray bar.

- Water Pump
A separate water pump will be needed if none are fitted to the water tankers. The pump should be of sufficient capacity to fill the tankers quickly.

- Other Vehicles
Transport for the supervisor.

- Tools
- Camber board made as shown from 20 mm treated plywood or hardwood to give the required slope e.g. 1 in 20 (5%) slope.

A selection of hand tools, as required.
Signs and Safety Equipment
The following items should be used where possible.

- Traffic Signs
  - 2 ‘Men Working’ signs.
  - 2 ‘End of Restriction’ signs.

These should be clean and in good condition.

- Clothing
  The workers should wear yellow or orange coloured safety vests.

- Lights
  The grading equipment should work with headlights switched on and, where possible, yellow flashing warning lights.

- Flags
  If yellow flashing warning lights are not available, vehicles and equipment should carry a red/yellow flag.

Important Rules
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 a compaction plant is being used, it must follow the grader only on sections where grading has been completed. About 8 to 12 passes of a roller, depending on the type of gravel, will be needed to achieve full compaction. Work from the edge to the centre of the road.

- Shoulders are treated as part of the running surface.
- Junctions and bends - graders must not stop 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 centred, the camber is correct. If it is not centred, the camber is either too steep or too flat and further grading and compaction are required.

**Super Elevation**

On bends, the surface must be straight (at 4-6%) from shoulder to shoulder with the outer shoulder higher. Any crown on a bend can be very dangerous to traffic.

The super elevation must be retained for the complete length of the bend. On the transition at each end of the bend into the straight sections, the super elevation should be gradually reduced.

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.

Bridge decks should be kept free from gravel. Loose material should be swept away. 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.
Grading Ditches and Drains

Before the road surface is graded, the side ditches must be cleaned. Narrow flat-bottomed ditches are not well suited to maintenance by grader. These are best cleaned out by hand. Graders should be used to maintain V-shaped ditches and wide flat-bottomed ditches. Material from the ditch should not normally be graded onto the running surface.

- The first pass cleans the side slope near the road and windrows the material to the bottom of the ditch.
- On wide flat-bottomed ditches, the second pass cleans the ditch bottom.
- The next pass cleans the ditch back slope and removes the material to the top of the ditch.
- If possible, a third pass is used to push the material away from the edge of the ditch, to prevent it washing back.

Fig: 30
Super elevation transition on curves
4.2 Labour-Based Reshaping

The task is to restore the shape (reshaping) of earth and gravel roads by Labour-Based Methods. The task and objects are the same as that of equipment intensive methods.

Defects

Defects are the same as that of equipment intensive methods.

Resources

Personnel

- 1 Supervisor visiting regularly.

Workforce

- 1 or 2 overseers for each section of road.

Plant and Tools

- 1 pickaxe.
- 1 shovel.
- 1 mammoty.
- 1 rake.
- 1 hand rammer with metal shoe.
- 1 wheelbarrow.
- 1 ditch and slope template and spirit level.
- 1 camber board and spirit level.
Signs and Safety Equipment

On low volume roads the following should be provided:

- Traffic Signs
  - 2 'Men Working' signs.
  - 2 yellow/orange flags to be placed on the road shoulder.

- Clothing
  - Yellow or orange coloured safety vest to be worn by the workers.

Execution of Work

The Supervisor transports the tools and safety items to the site using the wheelbarrow. The warning signs or flags are placed either side of the worksite. The workmen or lengthman trims the surfacing material with the pickaxe, hoe or mammoty and rakes it 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 the wheelbarrow. The loose material is compacted with the hand rammer.

Personnel

Supervisors
- 1 Overseer.
- 1 headman for each 10 to 20 workmen (usually from the local workforce).

Workforce
- 20 to 40 workmen.

Support (as necessary)
- Water carriers.
- Storeman.
- Watchmen.
- Hand tool sharpening and repairs.
Major Reshaping

Plant and Tools

Approximate requirements, actual number will depend on conditions.

- 1 pickaxe for every 10 workmen
- 1 hoe for every 2 workmen
- 1 mattock for every 10 workmen
- 1 shovel for every 2 workmen
- 1 rake for every 5 workmen
- 1 hand rammer for every 10 workmen
- 1 wheelbarrow for every 10 workmen
- 1 bush knife for every 10 workmen
- 2 crowbars
- 4 files (for sharpening tools)
- Axe
- Saw
- Grass Slasher
- 10 ranging rods and adjustable profiles
- 1 tape measure (30 metre)
- 1 camber board and spirit level
- 1 ditch and slope template
- 2 mason’s hammers
- Wooden pegs
- Balls of string/sisal twine
- If available, a hand or animal drawn roller

### 4.3 Patching
Patching is sometimes required between grading and reshaping operations, or before grading when the potholes or depressions are large. Patching may either be used to repair worn or eroded areas or can be used to restore areas, which become soft when it rains. This maintenance activity consists of replacing or adding new gravel surfacing material over relatively small areas. Patching may be carried out by a mobile gang or by labour based methods. Patching is normally used to refer to resurfacing work involving less than 1 or 2 truck or trailer loads of material per day.

**Defects**

Patching is used to correct:
- Potholes
- Ruts
- Soft Spots
- Erosion Gullies

Where there are a large numbers of potholes, the section will need scarifying with a self propelled grader.

**Re-Gravelling**

**Personnel**
- Supervisors
- Charge hands
- Plant Operators and Drivers
- 1 Driver

**Workforce**
- 2 to 6 labourers
- 2 Traffic Controllers

**Plant and Tools**
- Vehicles
- 1 small truck

OR
- 1 tractor and trailer(s). If two trailers are available, one trailer can be loaded while the other is hauled to the worksite.

**Compactors**
- 1 hand controlled vibrating roller and fuel OR
- 1 hand rammer with metal shoe for each labourer used on compaction work
Tools
- 1 broom for every two labourers
- 1 pickaxe for every two labourers
- 1 shovel for every two labourers
- 1 mammoty for every two labourers
- 1 rake for every two labourers
- 1 wheelbarrow
- 1 hand rammer with metal shoe for each labourer used on compaction work (if no vibrating roller is available)
- 1 drum for water (200 litre)
- 1 bucket or watering can

Materials
- The gravel must be at least as good a quality as the material already surfacing the road. Its use must be approved by the Maintenance Engineer.

Water
- A container will be required.

**Signs and Safety Equipment**

The following items should be provided where possible.

Traffic Signs
- Reversible 'Stop/Go' signs
- 2 'Speed Limit' signs (50 km/hr)
- 2 'Men Working' signs
- 1 'Road Narrows From Right' sign
- 1 'Road Narrows From Left' sign
- 'End of Restriction' signs

Barriers
- Lane closure barriers

Traffic Cones
- As many as required; at least 10 will usually be required.

Clothing
- Yellow or orange coloured safety vests or safety harnesses to be worn by the Supervisor and all the work force.

Vehicles
- All vehicles and equipment should work with headlights switched on and, where possible, should carry yellow flashing warning lights.

Flags
- If yellow flashing warning lights are not available, each vehicle and item will have a yellow flag.
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 slightly above the level of the surrounding road. Both large and small areas to be patched are repaired in the same way; the rammer is used for the smaller potholes. The roller is used for larger areas; the hand rammers will still be required for the corners and short edges.

4.4 Re-Gravelling (Labour and Tractors)

This is the most commonly used technique for the re-gravelling of running surface. Haulage is carried out by agricultural tractors of 45 hp (34kW) or greater, and gravel trailers. Tractor drawn rollers provide compaction. This method is usually appropriate for gravel hauls up to about 10 km. For haulage distances greater than 10 km, trucks are usually more economical. However, these may be loaded manually.

The surfacing material of unpaved roads is worn away by traffic, eroded by rain and blown away as dust. Before all the gravel surfacing has worn away, the road requires re-gravelling. Re-gravelling is normally a periodic maintenance task. It is important that the Maintenance Officer plans re-gravelling work well in advance so that work is carried out before serious defects appear. Before re-gravelling is carried out, it is important to make any necessary repairs or improvements to the camber and drainage system of the road. If this is not done, the new gravel surface will deteriorate very quickly. Re-gravelling is normally carried out with one layer of 15 cm thickness. Usually a continuous layer of gravel is laid on the existing running surface, however, on some occasions short stretches showing severe defects are covered under a spot re-gravelling operation.

Re-gravelling is used to correct
- Loss of surfacing material

Defects
Re-gravelling is needed before the subgrade is exposed on the road surface. Re-gravelling is also used to correct
- Loss of shape
- Ruts
- Potholes
- Erosion Gullies
Resources

Personnel
- Supervisors.
- 1 overseer at the quarry.
- 1 overseer at the road site.

Plant Operators and Drivers
- 1 driver for each tractor.

Workforce
- Depending on the number of tractors and haul distance.
- Mechanics for daily servicing and repair.
- Water carriers.
- Storeman.
- Watchmen.
- Hand tool sharpening and repairs.

Plant and Tools
- Tractors. The number of tractors required will depend on the gravel haul distance and plant availability.
- Additional tractors may be required for hauling rollers.
- Water and fuel.

Trailers
- 2 trailers per tractor if possible. This allows one trailer to be filled while the other is hauled to the road site. 33 metre capacity trailers are most suitable for 45 to 75 hp (34 to 56 kW) tractors.

Other Items
- 1 towed deadweight roller or hand operated vibrating roller.
- 1 towed water bowser.
- 1 towed fuel bowser.
- Light vehicles for the transport of the two supervisors.

Tools - typical hand tool requirements for a workforce of up to 100 labourers.
- 70 shovels
- 20 hoes
- 50 mammoties
- 50 pickaxes
- 10 bush knives
- 5 wheelbarrows
- 8 crowbars
- 20 rakes
- 4 sledgehammers
Materials

Gravel obtained from a quarry or gravel pit must be of a quality that meets the specifications.

Support and Safety Arrangements

Arrangements should be made, as necessary, for the following:
  a) Recruitment of workmen.
  b) Setting up temporary site camps.
  c) Facilities, secure hand tool storage, water supply.

Signs and Safety Equipment

As in the previous case.

Before starting the job, a check should be made to ensure that everything is arranged as necessary. Identify gravel source, test material and make any acquisition arrangements. Arrangements must be made for refuelling on site.

Temporary Signposting

As in the previous case.

Execution of the Work

The following steps are normally required:

  • Daily planning.
• Preparation of road surface.
• Preparation of quarry access road.
• Gravel excavation and stockpiling.
• Loading.
• Hauling.
• Offloading and spreading.
• Compaction.
• Stockpiling gravel for routine maintenance.

When using a large labour force, it is essential to break the work down into simple manageable operations to achieve satisfactory productivity.

Daily Planning
The deployment of tractors and trailers and the number of labourers for each activity depend on:
• Quantity of gravel already stockpiled.
• The haul distance.
• Number of serviceable tractors and trailers.
• Tractor power.
• Haul route condition.

The plans for each day should be prepared at the end of the preceding day’s work. Tasks should be set based on local experience.

Site Preparation
Wherever possible, before the re-gravelling work starts, a diversion if necessary should be arranged.

Preparation of Surface
After signs have been placed, the existing surface should be reshaped to the correct camber as described. If possible, the reshaped surface should be compacted. The camber should be checked with a camber board. The drainage system should be checked and repaired if necessary.

Preparation of Quarry and Access
Plan the quarry excavations and stockpiles so that: the quarry can be fully exploited; the overburden is stockpiled so that it will not hinder future extension and that it can be used to reinstate the quarry. Gravel quality may vary within the quarry. Environmental damage by poor drainage and erosion should be minimised. Allow the tractors and trailers to enter and leave without obstructions.

Repair the quarry access road, if necessary. Gravel should be excavated and stockpiled at least one day before. In addition, it should be excavated and stockpiled alongside to allow easy loading. In hillside quarries, excavate material to ease loading and ensure safety of workmen. Workmen must have enough room to work safely and comfortably.

Loading
Where possible, trailers should be parked at the same height as, or preferably below stockpiles for ease of loading. The loading gang should be divided into groups of 4 to 6 workmen.
Hauling
Gravelling should commence from where the quarry access joins the road to be re-gravelled.

Offloading and Spreading
It is important to offload the trailers as quickly as possible. Usually no more than 4 workmen can comfortably work on a trailer at a time. Any gravel lumps or stones larger than 5cm should be broken down using sledgehammers or removed.

Compaction
If available, the gravel layer should be watered using the towed water bowser before compaction. Compaction should be carried out with a tractor drawn deadweight roller or a hand operated vibrating roller.

4.5 Dragging (Improvised Substitute for Mechanized Grading)
During long periods of dry weather, dragging the road surface can be an effective means of making the road profiles smoother for passage of vehicles and in retarding the formation of corrugations. The objective is to make a light trimming cut and remove loose material from the surface.

Dragging can be done by means of an improvised towed grader. Alternatively, it has been found that some simple homemade tools and equipment are effective for the smoothing and shaping of unpaved road surfaces. The simplest drags may be timbers, logs, heavy brush or a set of tyres. These are effective for sandy surfaces, but may be less effective on harder surfaces. More sophisticated devices are made of scrap metal and wood with metal cutting edges, with additional weights added if required and pulled by animals, small tractors or by lorries.

There is room for innovation in the design, construction and use of these drags for dragging.

In the dry season, regular and frequent dragging can level out minor deformations in the road surface by spreading loose material over the surface. However, dragging is more effective with a small but optimum amount of moisture. If water is available, moisten the surface. An improvement to dragging is to compact the reshaped gravel road with a heavy roller, but this is normally too costly. Other methods of compaction may be used. However, leaving traffic to compact the surface is not very satisfactory as it is limited only to the wheel tracks.

![A General Arrangement of a Drag](image-url)
The need for heavy grading can be delayed by dragging regularly and frequently. Except for a sandy soil, however, dragging cannot remove corrugations, once they are formed. Nor will dragging restore camber or lost material.

**Procedure for Dragging**

The drag, sufficiently weighted, is set at an angle to the centre line of the road to transfer material from the edges towards the centre. The drag is towed by a tractor at 5 to 10 km/h, depending on the type of drag and on the type and condition of the road surface. This is repeated to cover the width of the road. The drag should not be pulled too fast along the road as it will jump over the irregularities without correcting them.
SESSION 5: MAINTENANCE OF PAVED ROADS

Road Cross Sections

Fig: 41 Paved Road Section

Fig: 41a Unpaved Road Section

1. SUBGRADE
2. ROADWAY
3. CARRIAGEWAY
4. SHOULDER
5. CAMBER/CROSSFALL
6. SURFACING
7. ROADBASE
8. SUB-BASE
9. PAVEMENT
10. EMBANKMENT
11. CUTTING
12. BASE GRADE
13. ORIGINAL GROUND LEVEL
14. CUTTING SLOPE
15. EMBANKMENT SLOPE
16. DITCH INSIDE SLOPE
17. DITCH OUTSIDE SLOPE
18. DITCH INVERT
19. ROAD CENTRELINE
20. GRAVEL SURFACE (WHERE CONSTRUCTED)
21. V-DITCH
22. TRAPEZOIDAL DITCH
5.1 General Repairs

General repairs are normally a routine maintenance activity. However, they are also carried out in advance of some periodic maintenance operations. The term General Repairs covers all types of work on the road pavement of a localised nature and of limited size.

Objectives

- Improve the surface condition of the road.
- Improve the pavement structure.
- Prevent water penetrating the pavement structure.

General Repairs must be carried out in a timely manner in order to prevent further deterioration, resulting in danger to traffic and leading to disintegration of the pavement. Engage simple methods and cover a large range of small work operations. A mobile gang using the required materials, skill and safety requirements usually carry out this task.

5.2 Techniques

- Sanding
- Local sealing
- Crack sealing
- Filling depressions
- Surface patching

In the case of surface repairs, bituminous binders, sand and aggregates are used. In the case of repairs to the pavement structure, natural or crushed materials and cold bituminous mixtures are used.

Defects

Defects can occur in:

The road surface
- Wear of the surface layer of the road.
- Cracking of the surface layer.
- Bleeding of binder to the road surface.

The pavement structure
- Deformation.
- Potholes.

Main Causes of Defects

The main cause of defects is the lack of regular maintenance.
Remedies: usual repair treatments.
Bleeding

Main causes
- Too much binder.
- Unsuitable binder.

If neglected, the road surface becomes slippery when wet and under the action of traffic, the surface layer separates and breaks away.

Remedies
- Sanding.
- Surface dressing.

Cracks in the Surface and in the Pavement Structure

- Longitudinal: parallel to the centre line (often along the wheel tracks or along the edges of the surfacing).
- Transverse: perpendicular to the road direction (across the whole or part of the cross-section).
- Mesh cracking: intersecting cracks dividing the pavement surface into isolated elements of different sizes down to the small elements.

Main Causes
- Poor quality materials.
- Poor workmanship.
- Insufficient pavement thickness for the traffic load.
- Shrinkage.
- Pavement age.

If neglected
A general or local destruction of the pavement.

Remedies
- Surface cracking: local sealing or filling-in of the cracks.
- Cracks in the pavement structure: local sealing or filling-in of the cracks and patching in cases of severe cracking.
Ruts and Depressions

Main Causes
- Insufficient foundation or pavement strength for the traffic being carried.
- Inadequate stability of the bituminous surfacing materials.

If neglected
- Water penetrates into the body of the pavement, and there will be a rapid increase in the degree of rutting, often leading to cracking and breaking up of the pavement.

Remedies
- Slight rutting (less than 5 cm): filling in of the ruts and depressions.
- Deep rutting: local restoration of the pavement structure.

Edge Subsidence and Rutting

Main Causes
- Inadequate or badly maintained shoulder.
- Penetration of water into the pavement structure or foundation and resulting loss of bearing strength.
- Poor drainage.
- Narrow carriageway.

If neglected
- Disintegration of the edges of the pavement.

Remedies
- Slight subsidence (less than 5 cm): filling in of ruts and depressions and restoration of shoulder.
Deep subsidence: local restoration of the pavement structure and restoration of the shoulder. Also consider improvements to the drainage or sealing of the shoulder to help prevent the problem from recurring.

Defect
Edge damage

Fig: 46 Degradation of pavement structure along the edges of the pavement

Main Causes
- Wear of the shoulder.
- Action of water.
- Insufficient compaction of the edges of bituminous pavements.
- Road too narrow.

If neglected
- Rapid deterioration during the rainy season.

Remedies
- Local restoration of the pavement structure.

Local Aggregate Loss

Fig: 47 Local aggregate loss to small areas or strips of the road surface

Main Causes
- Loss of surface aggregate; insufficient binder due to faulty spray jet.
- Aggregate dirty when laid.
- Insufficient penetration of aggregate.
- Poor premix quality or workmanship.
If neglected
• Minor stripping/fretting/streaking.

Remedies
• Surface patching.

**Potholes**

![Fig: 48  Degradation of the pavement structure in areas showing cracks, deformation or aggregate loss](image)

Main Causes
• Poor quality of material used for the construction of the pavement.
• Infiltration of water.
• Break-away of material under the action of traffic.

Final stage in the development of a depression.
If neglected
• Progressive enlargement of the hole and formation of additional potholes.

Remedies
• Local restoration of the pavement structure.

**Shoving or Mounding**

Defects in the surface or pavement structure similar in every respect to depressions and ruts.
5.3 Resources for General Repair

Workforce
1 Supervisor
1 spray gun/bitumen operator
2 to 4 workmen
2 Traffic Controllers
1 patching vehicle driver
1 tipper/flat bed truck driver
1 vibrating roller operator

OR
1 tractor driver
1 vibrating plate operator

Plant Tool
Patching Vehicle - a suitable means of heating and applying the bitumen (unless bitumen emulsion is used) is required e.g. towed bitumen heater/distributor.
Tipper or Tractor and Trailer - for transporting the aggregates, small items of equipment and personnel.
A small vibrating roller (or a vibrating plate compactor or hand rammers) - for use in compacting the aggregates and other materials.

Small Items of Equipment, Tools and Supplies
Small Items of Equipment
2 wheelbarrows
4 shovels
4 pickaxes
2 hand rammers
4 brooms
2 watering cans
2 squeegees
Bitumen thermometer

If bitumen emulsion is used, cold emulsion single drum sprayer.

Tools and Supplies
1 drum of diesel oil for use in cleaning the sprayer and other tools
1 spare jet for the spray lance
1 box of tools for use in dismantling the spray gun
Rags
A number of paintbrushes
1 metal bucket
1 two-metre straight edge
Chalk for marking

**Materials**

The materials used consist of aggregates and bituminous binders that are either applied separately or in the form of a bituminous mixture.

The aggregates may be:
- Sand
- Chippings

The materials should meet the grading requirements. The maximum size of aggregate varies according to the type of work involved, normally less than 2 centimetres.

Bituminous binder can consist of:
- A cold bitumen emulsion.
- A hot or cut back bitumen.

**Bitumen Binder**

The bituminous binder is applied with a spray bar or by hand from a container, to cover the surface and ensure that it will be impervious to water. The bitumen film is covered with stone chippings or aggregates to provide protection from traffic.

**Bituminous Mixtures**

The bituminous binder is used to bond the other materials together.

Bitumen mixtures can consist of:
- Cold bitumen emulsion mixtures – manufactured in advance of their application.
- Hot or cut back bitumen mixtures (hot mix) applied immediately after manufacture.

### 5.4 Maintenance Methods

Successful results for General Repairs depend on good preparation and organization of the work.

There are three preparation activities:

1. Examine the section of road to be repaired. The section of road to be repaired must be examined along its whole length in order to determine:
   - The types of defect to be repaired.
   - The extent of the defects.
   - The resources required.
2. Before the work starts, it is necessary to ensure the availability of:

- All necessary personnel.
- All equipment in good condition.
- All hand tools and the necessary traffic signs.
- The required type and quantity of binder.
- Aggregate in storage.

3. Temporary Signposting

Traffic signs conforming to the regulations must be correctly placed (as discussed previously) before starting any work. This is to ensure the safety:

- Of the road users.
- Of the personnel working on the site.
- Of the vehicles and equipment to be used on the site.

Execution of Works

Sanding

Sanding is the treatment to be used where the road surface is bleeding. Coarse sand up to 5 to 6 mm should be used where possible. Two activities, which may need to be repeated, are involved in the treatment:

- The sand is scattered by shovel over the affected surfaces from a truck or trailer.
- The sand is then spread out with a broom so that the surface is evenly covered.
Local Sealing

This treatment is used to repair cracks. It is also employed as the final treatment in the case of any local repair to the road. The treatment is applied in four stages:

1. Sweep the area. This is carried out by hand. The road surface must be clean and dry.
2. Mark out the area to be sealed. The surfacing that is to be covered is outlined in chalk.
3. Distribution of the binder. The binder is distributed over the surface using a spray can or a watering can. It is important not to overheat the hot cut back bitumen as this will affect its durability. A thermometer should be used to check the temperature during heating.
4. Distribution of the aggregate. The aggregate is scattered by shovel from the trailer. The material used is:
   - Coarse sand up to 5 to 6 mm, when dealing with cracks.
   - Chippings (such as 6-10 mm size) for local surfacing repairs.

The whole surface must be covered.

**NOTE:** When chippings are applied, they must be compacted with a small roller.

Cracking Sealing
This is an alternative treatment used to repair closely spaced cracks. The cracks are filled in with bituminous slurry in four steps:

1. Sweep the area: this is carried out by hand.
2. Mark out the area to be repaired: the area to be repaired is outlined with chalk.
3. Production of the slurry:
   The slurry is produced by mixing bitumen emulsion with coarse sand, up to 5 mm or very small gravel up to 1/4 minus, in a wheelbarrow in the following proportions:
   - Sand 20 litres
   - Emulsion 6 litres
   The emulsion drums will require rolling to thoroughly mix the contents before use.
4. Spreading the slurry: this is carried out with a squeegee. The material must be spread out in a thin layer, approximately 5 mm thick, over the whole of the marked area. The slurry must be allowed to dry completely before allowing traffic to pass over the repair.
This treatment is applied to deal with subsidence and surface irregularities due to Shoving and Ruts. The depressions are filled with cold mix asphalt, prepared in advance and stored at the depot. The repair is carried out in six steps:

1. Sweep the area: the depressions must be swept out by hand. The surface of the depression must be clean and dry.
2. Mark out the area to be repaired: the surface area of the depression that is to be filled in must be outlined with chalk. Remove any high spots with a pickaxe.
3. Obtain the cold mix.
4. Application of a tack coat: hot cut back bitumen or emulsion is applied with a sprayer or watering can.
5. Fill in the depression: the cold mix is placed within the marked outline using a rake and leaving an excess thickness of about one third of the depth of the depression in order to allow for compaction.
6. Compaction of the material: the material is compacted thoroughly using a small vibrating roller, plate or manually using a hand tamper, until the level is 3 mm above the surrounding surface.
7. Resealing: the repair must be sealed to prevent penetration of water.

**Surfacing/Patching**

This treatment is used to repair local aggregate loss and is carried out in the following steps:

1. Sweep the area: the area must be swept out by hand. The surface must be clean and dry.
2. Mark out the area to be repaired: the surfacing that is to be repaired is outlined in chalk.

**Optional Sealing**

Use cold emulsion or hot cut back bitumen to seal the area to be repaired and provide a tack coat. Apply the chippings (such as 6-10 mm size) and ensure a complete coverage. Lightly roll the chippings into the bitumen using a roller.
Option 2 - Premix A

Hot cut back bitumen is applied to the area of the repair with a sprayer or watering can to fully 'wet' the area. Spread fine cold mix (made from material up to 5-10mm size) evenly over the area and compact it level with the surrounding surface using a small vibrating roller, plate or a hand tamper/rammer.

**Base Patching (Deep Patching)**

This is the treatment that is used to repair:
- Mesh cracking
- Ruts and depressions
- Edge subsidence and rutting edge surface failure
- Potholes
- Shoving

Four steps are involved:
1. Marking out the area to be repaired: the area to be treated is marked out with chalk.
2. Excavation of the area to be repaired.
   - Remove all material from within the marked out area of the road surface.
   - 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 and solid.
   - 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.
3. Backfilling the hole
   The hole is filled with a selected well graded material brought to the site and the material can consist of:
   - A material of the same quality as that of the base layer that is to be repaired.
   - Or cold mix asphalt manufactured with emulsion and not with cut back. The material is placed in the hole and compacted in one or more layers of regular thickness depending on the depth involved. 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 rammer, until the surface is level. Do not attempt to compact the patch with the wheel of a tractor or vehicle as this tends to get poor compaction and often moves the patch material.

4. Resealing
The repair must be sealed to prevent penetration of water.

5.5 Surface Dressings Mechanized

SURFACE DRESSING is normally a PERIODIC MAINTENANCE activity.

Application
A surface dressing can be used for dealing with a large road surface area where:

- The surface is extensively worn.
- The surface has become permeable or cracked allowing water to penetrate the base and cause deterioration.

It will usually be necessary to carry out some patching work before proceeding with this operation, particularly where there is base damage, subsidence, potholes etc.

- The surface dressing is generally applied.
- Surface dressing must be applied only in dry weather.

Surface dressing will not correct depressions, deformation of the road pavement or severe cracking.

Different Types of Surface Dressings
1. Single surface dressing / SBST
   - 1 layer of bituminous binder
   - 1 layer of chippings.
2. Double dressing/ DBST
   - Layers of bituminous binder, each covered with a layer of chippings.
3. Graded seal
   - 1 layer of bituminous binder, followed by layers of chippings of different compatible sizes e.g. 10/14 and 4/6 respectively. The second layer serves to fill the gaps between the larger first stones and completely covers the road surface.
   This seal is suitable for existing surfaces with extensive bleeding.

**Defects**
Defects treated by surface dressing are usually those involving large areas of the road surface:
- Wear of the surface layer.
- Cracked surface.
- Bleeding of binder to the surface.

The use of a surface dressing can sometimes prevent any increase in the deformation of the pavement structure (preventive treatment).

Main causes of the defect: maintenance work not regularly carried out.
Remedies: usual repair treatment.

**Bleeding**

Main causes: Development
Remedies: same as previously discussed.

**Cracks**

Main causes: lack of maintenance.
Remedies: same as previously discussed.
Loss of Surface Aggregate

Main causes
Breakaway of surface aggregate or seal due to:
- Poor adhesion of the surface dressing to the base.
- Aggregate dirty when laid.
- Insufficient penetration of aggregate.
- Poor premix quality or workmanship.
- Insufficient or incorrect distribution of binder.

If neglected
- Progressive breakaway of chippings resulting in the surface becoming more slippery, more permeable or worn out by traffic.

Remedies
- Application of a surface dressing or
- Application of a thin bituminous overlay.
**Streaking**

Parallel to the centre line and extending over appreciable lengths.

Main cause
- Faulty operation of the spraying equipment applying the surface dressing, giving rise to streaks of insufficient binder.

If neglected
- The surface will become more permeable and potholes or deformation will probably occur.

Remedies
- Application of a surface dressing or
- Application of a thin bituminous overlay.

**Deformations**

![Image of pavement deformations]

Fig: 61 Various forms of local settlement of the pavement, usually along the wheel tracks or along the edges of the road

Main Causes
- Insufficient strength of the pavement structure or foundation.
- Inadequate stability of the surface layer (bituminous mixture).

If neglected
- Rapid increase in the settlement during the rainy season and a break up of the pavement if water penetrates the base.

Remedies
- Slight subsidence - application of a surface dressing as a preventive measure.
- Appreciable subsidence - patching, followed by the application of a surface dressing or a thin overlay.

**Resources**

- 1 Supervisor
- 1 spray bar operator
- 1 supervisor for aggregate trucks
- 2 - 4 chip spreading labourers
- 2 Traffic Controllers
Plant Operators and Drivers
1 mechanical broom operator
1 bitumen distributor driver
4 aggregate truck drivers
2 roller operators
1 loader operator (for the loading of chippings)
1 truck driver
1 light vehicle driver

Plant and Tools
1 mechanical broom
1 bitumen distributor of 5,000 to 8,000 litres capacity, with working thermometer
3 or 4 aggregate trucks each of 5 to 6m³ capacity
2 rubber tyred rollers (pneumatic) with tyres inflated to a pressure of 6 kg/cm²
1-wheeled loader
1 light vehicle
1 tipper truck
Tailgate or self propelled type chipspreader

Test Equipment
Calibration tray and test equipment for measuring bitumen rate of spread.

Small Items of Equipment
2-4 shovels
Brooms
2 rakes
2 pickaxes
2 wheelbarrows

Tools and Supplies
Rolls of strong paper (at least 50 cm wide)
1 drum of diesel oil to clean the spray bar and tools
A number of spare spray bar jets
1 box of tools for use in dismantling the spray bar jets and adjusting the chipping
Equipment:
- Rags
- Paint brushes
- Metal buckets
- Chalk or paint for marking
- String

Materials
The materials required for surface dressing usually consist of:
- One or several types of aggregate (chippings).
- A bituminous binder.

Aggregates
- Aggregates are obtained from approved sources and must conform to the specifications.
- Meet grading standard, be of a suitable shape (preferably cubical) and be sufficiently clean. (Dirty or dusty aggregate will not adhere to the bitumen. If aggregates are dusty they should be washed).

Bituminous Binders
Different types of bituminous binders are available:
- Penetration grade
- Cut back bitumen
- Bitumen emulsions

Successful surface dressing depends on the degree to which the binder adheres to the aggregate (good bonding characteristics).

If on site it is found that the binder does not adhere well to the aggregate (poor bonding characteristics), then it will be necessary to:
- Stop work.
- Inform the responsible person.
- Collect samples of the binder and aggregate for use in carrying out further laboratory tests.
5.6 Maintenance Methods

Equipment

Prior to starting work, a check should be made to ensure that all equipment to be used are in good condition and that arrangements have been made to:

- Provide the vehicles with fuel.
- Carry out maintenance work on the equipment.
- Ensure all personnel are available.
- Ensure all hand tools and traffic signs are available.
- Supply the binder and aggregate, ensuring that the quality and quantity of these materials meet specifications.
- Ensure all bitumen heating equipment and pumps are available.

Check that the Preparatory Work has been carried out. The success of the surface dressing depends on the proper preparation of the existing surface. The General Repairs gang carries out this preparation. Before starting work, it is necessary to ensure that:

- Potholes have been repaired.
- The edges of the road have been repaired.
- That the existing surface is clean and free of dirt or other debris that would affect the bond of the new surface dressing (clean if necessary).

Organise the Work

Before work starts, the Supervisor inspects the condition of the existing surface for the last time to ensure that it is clean, properly repaired and that the edges of the road where they join onto the shoulder are properly defined.

Mechanical broom and the rollers are sent to the site. If possible, locate them off the road in order to protect both the road users and the equipment.
Temporary Signposting
Traffic signs conforming to the regulations must be correctly placed before starting any work, as discussed previously.

Execution of the Work
A surface dressing is usually applied to half the width of the road at a time. There are seven steps:
1. Sweep the complete road surface where the binder is to be applied so that it is perfectly clean.
2. Mark out the road surface - a string-line is run along the edge of the carriageway where work starts to ensure good alignment of the edge of the surface dressing.
3. Check and adjust the binder distributor
   - Check the temperature of the binder.
   - Check that all the spray bar jets are operating properly.
   - Adjust the height ‘h’ of the spray bar so:
Each point of the road is sprayed by binder from three separate jet. Adjust the angle of the spray bar so that it is parallel to the road surface to obtain a good transverse distribution of the binder. Adjust the width covered by the spray bar so that 1/3 of the spray coming from the last jet on the spray bar overlaps the centre line of the road. This will ensure that the correct amount of binder will be deposited along the centre of the road following the second pass of the binder distributor. The second pass of the distributor on the other lane must take place in the same direction.

4. Place strips of strong paper in position to ensure regular transverse joints at the beginning and end of each pass of the distributor.

Fig: 65

5. Distribute the binder - the binder must only be applied to a completely dry surface (application of surface dressing during the rainy season should therefore be avoided).
   - Position the distributor 10 to 15 metres from the beginning of the surface that is to be treated and line it up with the marked outer edge of the road.
   - Advise the driver of the speed at which he is to check gates on the sprayer truck.
   - The distribution of the binder can now start.
   - The distributor jets are opened over the first strip of paper and closed over the strip at the end of the run.
   - A test of the rate of spread of bitumen should be carried out during the spraying operation.
   - No person or vehicle must be allowed onto the surface sprayed with binder.

6. Distribute the Aggregate - the aggregate is distributed by driving the gritting trucks backwards as follows:

Fig: 66

   - For the first half-width of the road, aggregate is spread over the binder leaving a 20 cm strip uncovered along the centre line.
   - For the second half-width of the road, aggregate is spread over the remaining width of the binder including the strip left uncovered. Any adjustments to spread width are made by opening or closing the appropriate
tailgate flaps. If the sprayed width is wider than the full truck spread width, immediately cover the rest of
the binder. The distribution of the chippings is started immediately after the application of the binder such
that the distance between the binder distributor and the spreader truck never exceeds 75 metres (preferably
30 metres). Following the initial passage of the spreader truck, check that the complete surface has been
covered with aggregate, adding additional stone by hand if necessary. Then use brooms to sweep back any
aggregate that may have fallen onto the uncovered strip of binder or beyond the edge of the road. Remove
the strong paper laid at the beginning and end of the road section being treated.

7. Roll the Dressing - rolling is carried out using two rollers running backwards and forwards at a distance of at least
50 metres from the gritting trucks at speeds of not more than 8 km/hr. A number of passes (usually 5) of the rollers
should be made over the complete surface. When the rolling has been completed, providing it does not rain, the
treated section of road is opened for traffic.

All spraying equipment and tools must be thoroughly cleaned at the end of the day. Spray bars and nozzles should be
flushed out with diesel.

Completion and removal of temporary signposting

Finishing work is carried out during the week following the application of the surface dressing. There are four activities
required:
1. Place the traffic signs in position, as discussed previously. If traffic is heavy, barriers, cones and traffic control
should also be used.
2. Remove excess material as soon as possible. Excess chippings are removed by sweeping lightly by hand or with a
mechanical broom. If left on the road they can damage vehicles and shatter windscreens.
3. Sand any areas where bleeding has occurred. This is done by throwing coarse sand over the affected areas.
4. Remove the traffic signs. All traffic signs are removed on completing the final work.
SESSION 6: LOW COST TECHNIQUE

6.1 Introduction

The low cost techniques are more appropriate and easily adopted in rural areas where machinery and equipment are scarce or not available. Even if machinery and equipment are available some of the low cost techniques are easily introduced.

However, the words 'low cost' are mostly misunderstood in engineering construction. It should be emphasized that low cost construction techniques by no means allow low quality work or a reduction in the safety factor.

Low cost techniques can be separated into two categories depending on the usage.

- Low cost construction techniques.
- Low cost quality management techniques.

6.2 Low Cost Construction Techniques

Sand Sealing

The most commonly used periodic maintenance activity on the road surface in Sri Lanka is sand sealing. Sand sealing provides a way to help prevent water from penetrating through cracks and imperfections in the roadway surface that can destroy the road base.

The following procedure has been followed in sand sealing.
1. Barricade the area and put up necessary signboards for safety.
2. Clean the surface using brushes.
3. Patch the large potholes using premix.
4. Patch the tiny potholes with sand premix.
5. Apply CRS I uniformly over the surface at the correct rate.
6. Squeegee may be used for spreading uniformly and to prevent flowing of emulsion out of the carriageway.
7. Spread sand over the emulsion at the rate of one cube per 60 squares.
8. Roll properly to embed the sand.
9. Allow flow of traffic.

Scarifying and Compaction of Existing Surface

As a low cost method in the periodic maintenance, scarify the surface with the motor grader and compact the same with rollers and adequate water. This technique can be used for resurfacing badly neglected low traffic roads. However, prior to commencing work it is imperative that the drainage aspect of the road is attended to satisfactorily.

Equipment
1. Motor Grader
3. Static Rollers

Following sequence is recommended:
1. Scarifying the road surface.
2. Add 3/4" aggregate if the metal quantity in the surface is not sufficient.
3. Mix the scarified with 3/4" aggregate thoroughly using the grader.
4. Grade the surface to form the correct camber.
5. Compact thoroughly with the roller.
6. Apply 1st coat (CSS I) at the rate of 2.0 lt. per sq. metre.
7. Subsequently after leaving at least 12 hrs, sand seal the surface.

An average of about 400 - 500 metres of 4 metre carriageway could be constructed per day.

**Constriction of Culverts Without Head Walls**

Pipe culverts can be constructed in areas where the availability of ROW does not pose a problem. These culverts are constructed within a short timeframe and inconvenience to public can be greatly reduced. Since the construction of head walls is absent, the cost is drastically reduced and is about 40% of a conventional culvert.

![Diagram of Culvert without Head Walls](Fig: 68)

**Construction of Anchored Tyre Retaining Walls (with discarded tyres)**

![Images of Anchored Tyre Retaining Walls](Fig: 69)
Cost effective and environmentally friendly retaining structures can be constructed with discarded tyres, which would otherwise be an environmental hazard due to the problems encountered with dumping or burning them.

The foundation of the anchored tyre retaining structure is taken to a suitable depth in naturally stable ground. The unserviceable tyres (preferably of equal size) are placed on the foundation of the retaining structure along the face to interlock with each other, then tied together. Preferably soil with low plastic characteristics is placed inside the tyres and pushed into the tube spaces filling the total space, and compacted manually. This procedure is repeated by placing tyres one on top of the other, filling with soil and compacting till the fill in the foundation is well compacted.

A new row of tyres is placed above the ground level and tied using long-lasting ropes of suitable diameter. The anchor tyre is placed in the stable zone and every other tyre is tied to the anchor. The number of tyres tied to the anchor is limited to 4. The embankment is backfilled and compacted. This procedure is repeated until the required height is reached.

### 6.3 Quality Control Techniques

#### Selection of Good Gravel

The content of clay in a soil sample generally determines the suitability of the soil as a road construction material. In this method, the volume of washed aggregate is observed to indicate suitability.

1. A tin is filled to the brim with a selective sample of soil.
2. This sample is transferred to a thick cloth of suitable size and washed in water without allowing granular particles to be washed away.
3. Then the contents of the cloth, free from soil, are transferred back to the same tin.
4. Observe the new height of the granular residue in the tin. The percentage loss is an indicator of clay content in the sample. If the percentage loss is less than 10% the soil is of good quality and suitable for base and sub-base construction.

#### Check on Compaction

This method can be used when compacting gravel with a roller. When a roller is taken over a rod placed horizontally over a soil surface, the depth of the mark shown on the surface is an indicator of degree of compaction of soil.

Since the conclusion of degree of compaction is subjective the experience of the supervisor is imperative.

#### Checking of Cement Content in Concrete and Mortar Before Hardening

The colour is an indicator of cement content in raw concrete and mortar. In this method, cement sand and aggregate is mixed together with water in the respective correct proportion and compared visually with the mix that is being used on site.

A suitable tin or small container can be used as the measure.
REFERENCES

- Overseas Road Note 1
- Overseas Road Note 2
- Road Maintenance Manual Road Development Authority
- PIARC Road maintenance Hand Book