

INTERNATIONAL ROAD MAINTENANCE HANDBOOK



Volume IV

Maintenance of
Structures and Traffic
Control Devices

AIPCR



PIARC

INTERNATIONAL ROAD MAINTENANCE HANDBOOK

PRACTICAL GUIDELINES FOR RURAL
ROAD MAINTENANCE

Volume IV of IV

Structures and
Traffic Control Devices

Financed and coordinated by



Revised by R C Petts of **Intech Associates, UK**
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FOREWORD

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

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

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

FOREWORD continued

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

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

FOREWORD continued

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

A handwritten signature in black ink, appearing to read 'Victor J Mahbub', with a long, sweeping underline that extends downwards and to the right.

Victor J Mahbub,
President of PIARC.

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INTRODUCTION

THE HANDBOOK

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

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

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

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

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

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

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

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

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

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

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

- The task
- Defects
- Resources
- Maintenance method

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

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

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

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

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

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

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

handbook PERIODIC also includes certain improvement works such as thin bituminous overlays.

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

The HANDBOOK consists of 4 separate volumes:

**VOLUME I - MAINTENANCE OF ROADSIDE AREAS
AND DRAINAGE**

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

VOLUME II - MAINTENANCE OF UNPAVED ROADS

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

VOLUME 111- MAINTENANCE OF PAVED ROADS

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

VOLUME IV - MAINTENANCE OF STRUCTURES AND TRAFFIC CONTROL DEVICES

PART A - Bridges

PART B - Traffic Control Devices

VOLUME IV

This volume describes the maintenance of bridges (Part A), and traffic control devices (Part B).

The objective of bridge maintenance is to keep the structures in sound condition and safe for traffic.

Where a bridge spans a watercourse, the water must flow freely at all flood levels without damaging the bridge or the waterway.

The objective of traffic control device maintenance is to keep all signs, guide posts, markings and barriers in a good condition so that they fulfil their function. This will keep road users informed and help to make their travel as safe as possible.

PART A - BRIDGES

Routine and Periodic Maintenance activities are described which can be carried out by a gang without specialist skills or equipment. Major structural repairs are beyond the scope of this handbook and require specific skills for identification and remedy.

PART B - TRAFFIC CONTROL DEVICES

The necessary activities for cleaning, repair and replacement of traffic control devices are described.

Details of the standard temporary signs required for road maintenance works are provided.

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

Part A

BRIDGES



1. THE TASK

The task is to carry out:

- **Routine*** maintenance activities

and when necessary

- **Periodic*** maintenance activities (major repairs and improvements).

1.1 OBJECTIVE

The object is to keep bridges* in sound structural condition and safe for traffic.

Where a bridge spans a watercourse, the water must flow freely at all flood levels without damaging the bridge or the waterway.

*See *List of Terms, Volume 1*.



PART A - BRIDGES

1.2 ACTIVITIES

Routine* Activities

CLEANING/CLEARING

MINOR REPAIRS (STRUCTURAL)

- Repair of loose/missing connectors and fixings
- Replace damaged planks
- Painting
- Wood preservation
- Pointing masonry.

MINOR REPAIRS (SAFETY)

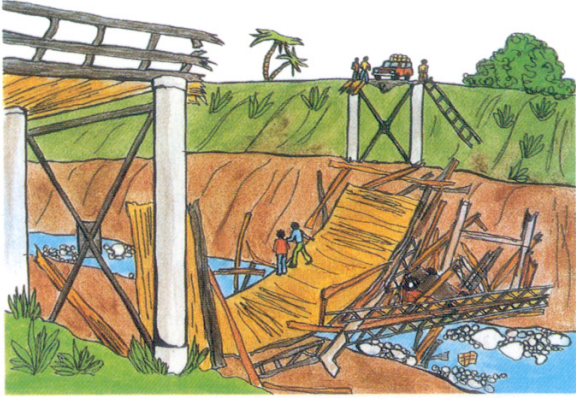
Repair barriers and safety features

Periodic *Activities.

MAJOR REPAIRS

- Random stone filling
- Retaining wall
- Riverbed scour* apron
- Gabions*.

**See List of Terms, Volume I.*



PART A - BRIDGES

2. DEFECTS

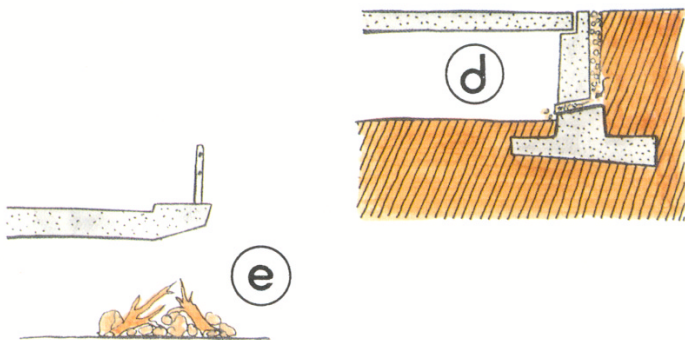
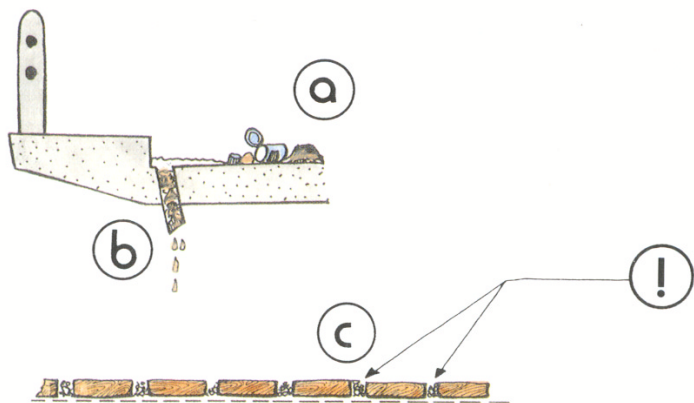
Defects in bridges should be detected early and repaired promptly. If they are neglected the resulting damage will usually require more extensive repairs or even lead to the collapse of the structure.

2.1 LIST OF DEFECTS

In order to properly remedy a bridge defect, its cause must be assessed. Only when the cause is known, is it possible to successfully cure the problem.

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

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



PART A - BRIDGES

MINOR DEFECTS

■ Minor Defects (Non structural)

- a) Accumulation of dirt and soil on bridge deck*
- b) Blocked scuppers*
- c) Stones, soil, dirt in joints and around bearings
- d) Vegetation, soil in weep holes or in backfill drainage*
outlets
- e) Flood debris at or under bridge
- f) Wind blown debris on or under bridge.

Main Causes

Poor routine maintenance.

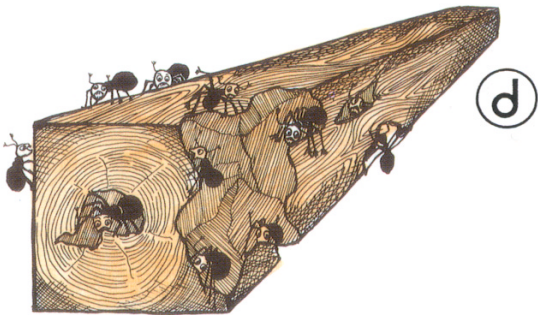
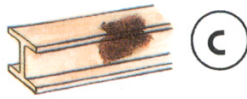
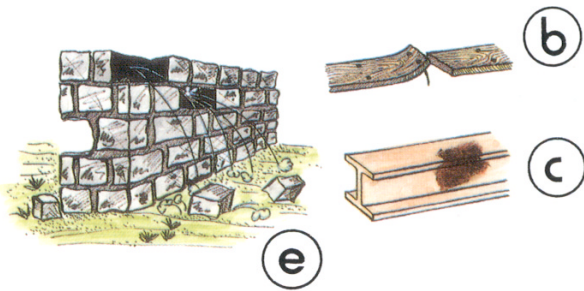
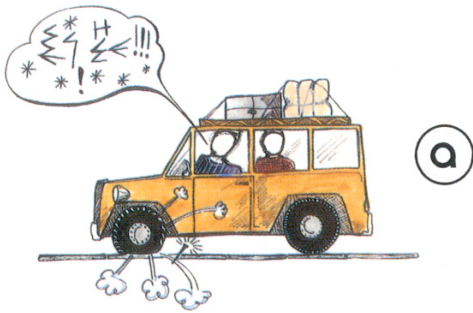
Development, if neglected

- a) Slippery road surface when wet, accidents
- b) Ponding of water on bridge deck, water penetrates
and attacks structure, accidents
- c) Bridge deck cannot expand or contract as designed,
structural damage
- d) Water cannot drain and backfill may settle, abutment*
may move under pressure
- e) Waterway opening becomes smaller, pressure build
up on piers/deck in floods, roadway floods, fire
hazard in dry season
- f) Accidents, waterway opening becomes smaller.

Remedies

Cleaning/clearing.

**See List of Terms, Volume 1.*



PART A - BRIDGES

MINOR DEFECTS

■ **Minor Defects (Structural)**

- a) Loose or missing nailed/bolted connectors or fixings
- b) Damaged running boards and deck planks
- c) Rusty steel, faded paint
- d) Untreated wood
- e) Defective masonry joints.

Main Causes

- a) Loss or loosening through age, action of traffic, rust, or poor workmanship
- b) Action of traffic, water, decay
- c) Weathering
- d) Lack of wood-preservation treatment
- e) Settlement, poor construction.

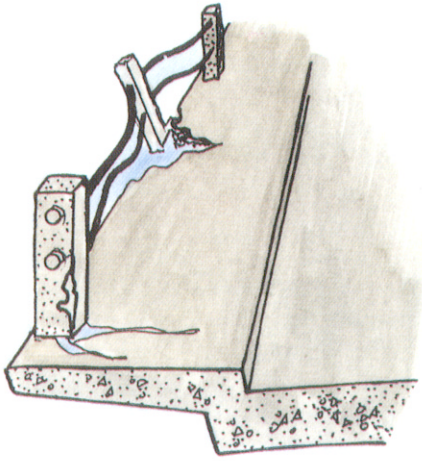
Development, if neglected

- a) Loss of planking and railing; weakened truss, damage to vehicle tyres
- b) Loss of planking
- c) Corrosion of steel member
- d) Loss of wood member by fungus or insect attack
- e) Local collapse of masonry structure.

Remedies

Minor Repairs (Structural)

- a) Repair of loose or missing connectors or fixings
- b) Replace defective planks
- c) Painting
- d) Wood preservation
- e) Pointing masonry.



MINOR DEFECTS

■ **Minor Defects (Safety)**

- a) Damaged safety barrier or parapet*
- b) Damaged warning signs

■ **Main Causes**

- a) Accident damage
- b) Accident damage, weathering

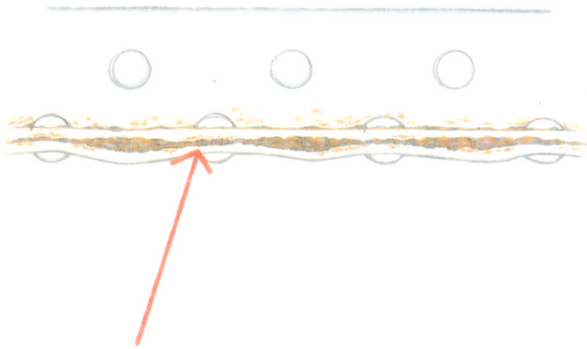
■ **Development**, if neglected

- a) Reduced safety for bridge users
- b) Reduced safety for bridge users

■ **Remedies**

- a) Repair barrier or parapet
- b) Repair or replace warning

*** See List of Terms, Volume I*



PART A - BRIDGES

MAJOR DEFECTS

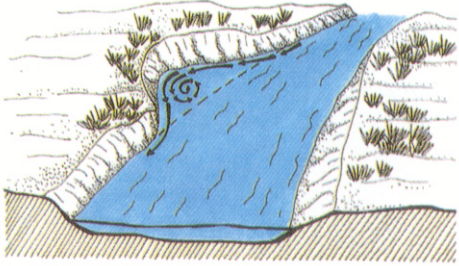
All major defects must be brought to the attention of, and inspected by, the Bridge Engineer or Inspector.

This Handbook deals only with the more straight forward major repairs relating to stream bed or bank erosion:

random stone filling
retaining wall
riverbed scour apron
gabions.

For any of the following defects the Bridge Inspector or Engineer must be informed, investigate and arrange detailed plans for appropriate remedies.

- structural timber decay, splitting or insect attack
- bulging masonry
- cracked concrete or masonry
- honeycombed concrete
- spalling concrete
- serious rust or chemical stains
- exposed or corroding reinforcement, or prestressing steel
- damp patches on the concrete
- seriously corroded structural steelwork
- damaged/distorted structural steelwork
- loose structural rivets, bolts or other fixings
- cracks in structural steelwork
- settlement of deck, piers or abutments
- erosion requiring piling works
- repairs to steel panel bridges (e.g. Bailey).



PART A - BRIDGES

Major Defect: **Erosion**

Stream bed or stream bank eroded

Main Causes

Fast water flow; undermining of unprotected soil banks by stream.

Development, if neglected

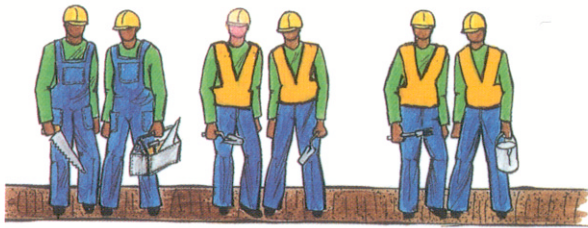
Undermining and settlement/washout of bridge* foundations and road embankment*.

Remedies

Waterway repair by means of:

- random block filling
- block masonry retaining wall
- riverbed scour apron
- gabions.

* See List of Terms, Volume I.



3. RESOURCES

These comprise personnel, plant and tools, materials, signs and safety equipment.

The following lists contain the resources that may be required on a regular or occasional basis. The manpower and items required on a particular day will depend on the maintenance operations being carried out.

3.1 PERSONNEL

■ Supervisors

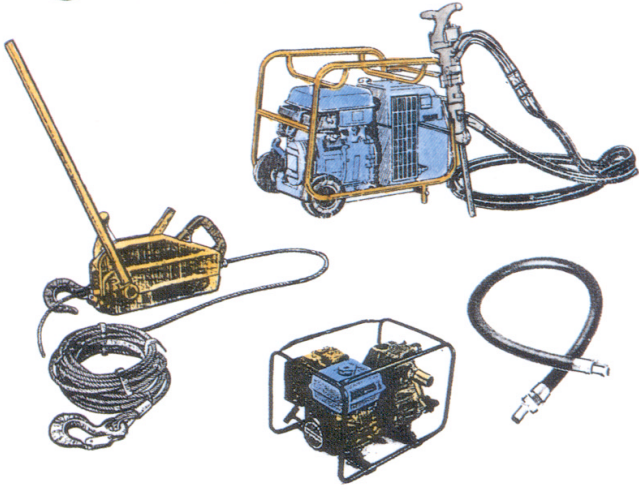
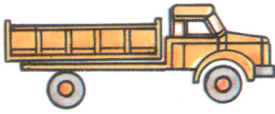
- 1 foreman/overseer.

■ Plant Operators and

- 1 truck driver.

■ Workfor

- 3 to 6 labourers
- 1 to 2 carpenters
- 1 to 2 masons
- 1 to 2 painters
- 1 to 2 steelworkers
- 1 to 2 skilled concrete workers
- 1 to traffic controllers.



PART A - BRIDGES

3.2 PLANT AND TOOLS

- 1 flat-bed truck (equipped if possible with winch and hoist*)
- 1 compressor with pneumatic breaker
- 1 to 2 winches
- 1 hoist
- 1 water pump
- 1 concrete mixer
- oxyacetylene burner
- extendable ladders

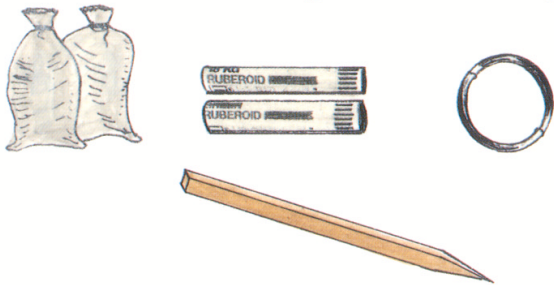
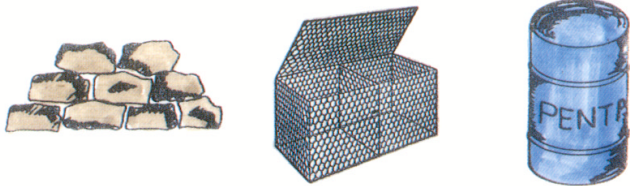
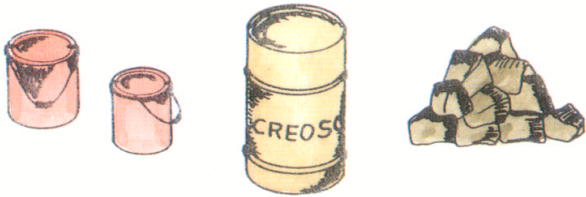
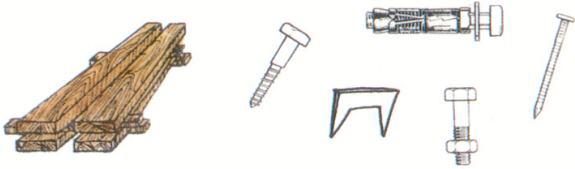
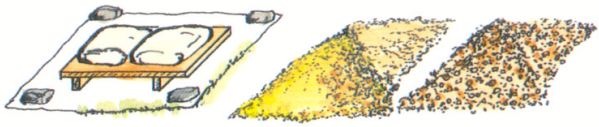
" See List of Terms, Volume 1.



PART A - BRIDGES

3.2 PLANT AND TOOLS Continued

- | | | | |
|---|-------------------|---|--------------------|
| - | shovels | - | spirit level |
| - | hand and power | - | bow-saw |
| | saws (for timber | - | wire brushes |
| | and steel) | - | scaffolding poles |
| - | rakes | | and fittings |
| - | crowbars | - | scaffolding planks |
| - | screw-drivers | | or boards |
| - | rope 50 m | - | temporary |
| - | assorted | | steelwork panels |
| | carpenter's tools | | (e.g. Bailey) |
| - | chisels | - | rivet dies |
| - | plumb-bob | - | sledge hammers |
| - | pliers | - | paint burner (blow |
| - | pickaxes | | lamp) |
| - | hammers (of | - | paint scrapers |
| | various sizes) | - | aggregate |
| - | torch light | | measuring box |
| - | wheelbarrows | | (equivalent to 1 |
| - | trowels | | bag of cement). |
| - | wrenches | | |
| | (spanners) | | |
| - | torque wrench | | |
| - | set of jacks | | |
| - | measuring tapes | | |
| - | straight edge | | |
| - | brooms | | |
| - | paint brushes, | | |
| | paint rollers | | |
| - | brace and drill | | |
| | bits | | |
| - | buckets | | |
| - | handbrush | | |



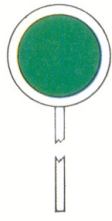
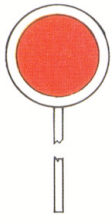
PART A - BRIDGES

3.3 MATERIALS

- cement (to be stored dry), plastic sheet
- concrete aggregates (sand and stone)
- timber, (assorted sizes)
- nails, screws, bolts, nuts, cramps
- rust protection paint (use red lead or zinc chromate primers or equal), selected finishing paints for steel, wood and concrete and paint solvents
- creosote-coaltar solution (or similar) for wood protection
- rock riprap
- masonry stone
- gabion* wire baskets
- 3 mm binding wire
- wooden stakes
- gabion filling stone
- jute or plastic sacks
- chemicals¹ for use against termites (white ants)
- bituminous felt (packing)
- chalk, or similar markers.

* See List of Terms, Volume I

¹ For example: Pentachlorophenol, or similar



2



2



1



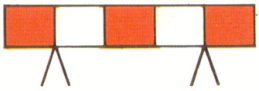
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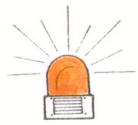
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2



2



3.4 SIGNS AND SAFETY EQUIPMENT

The following items should be provided where possible

■ Traffic

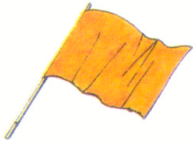
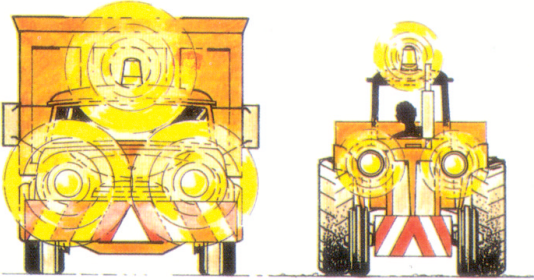
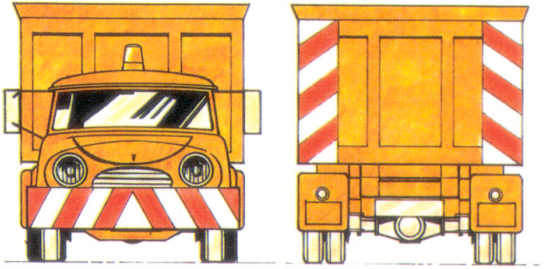
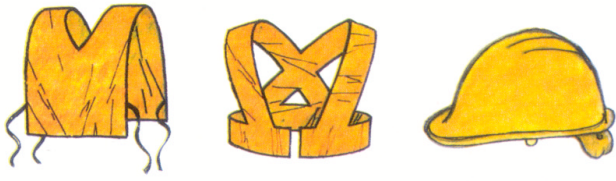
- 2 reversible "Stop/Go" signs, 2 "Speed Limit" signs (50 km/hr),
- 2 "Men Working" signs,
- 1 "Road Narrows From Right" sign,
- 1 "Road Narrows From Left" sign,
- 2 "No Overtaking" signs
- 2 "End of Restriction" signs,
- warning lights for night work.

■ Barriers

2 lane closure barriers.

■ Traffic Cones

As many as are required; 6 to 10 will usually be needed.



PART A - BRIDGES

■ **Clothing**

Yellow or orange coloured safety vests or safety harnesses to be worn by the supervisor and all of the work force.

Protective gloves should be provided for heavy duty and chemical handling activities.

1 lightweight safety helmet should be provided for each supervisor and workman.

1 first aid kit.

■ **Vehicles**

All vehicles and equipment working on the roadway should be painted yellow or orange and should carry red and white striped marker boards front and rear.

■ **Lights**

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 of equipment should carry yellow or orange flags.

TYPICAL WORKSHEET

BRIDGE MAINTENANCE

Worksheet No.: Date:

District:

Zone: Gang:

Road No.: from to

Bridge No.:

Location:

Work to be carried out:

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

Work to be completed by: (Date)

Signed:
(Engineer)/(Technical Assistant)

4. MAINTENANCE METHOD

4.1 PRELIMINARY TASKS

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

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

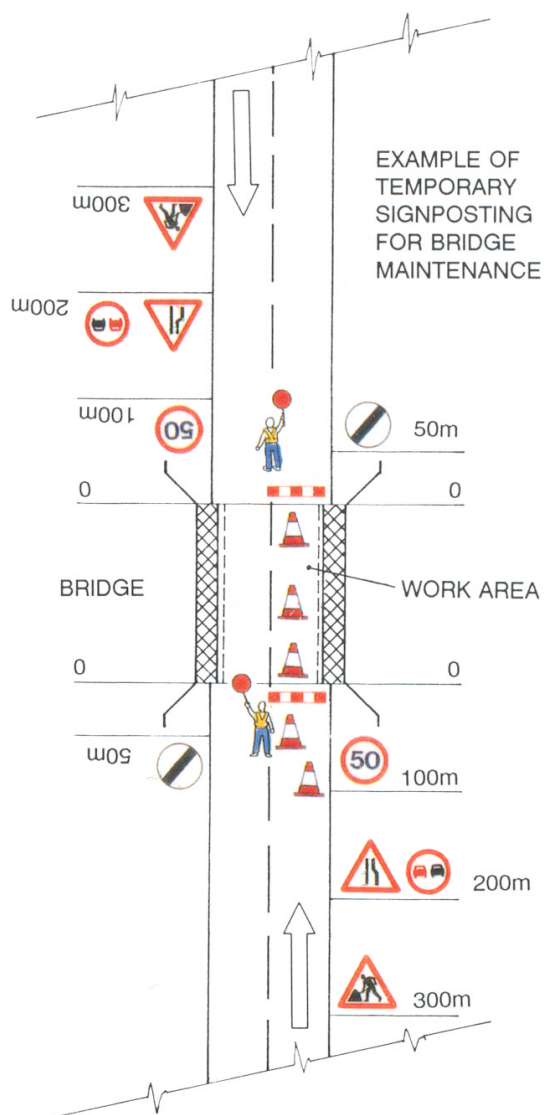
- The **manpower** required for the specified work must be arranged.
- **The truck** must be fuelled, checked mechanically and have water and oil levels checked.
- **The equipment, handtools and materials** required must be organised.
- **Traffic signs, barriers and cones** must be obtained and loaded onto the truck.



4.2 SAFETY MEASURES

Bridge maintenance work can be hazardous, especially when normally inaccessible parts of the structure have to be inspected or maintained. When ladders are used, always observe the following safety rules:

- always inspect a ladder before use,
- use only a ladder which is in good condition,
- never paint a ladder as this may hide defects,
- never use a spliced ladder or extend the ladder by splicing,
- the top of the ladder must always have firm support at both rails,
- the foot of the ladder must rest on a firm base,
- for best stability place the base of the ladder one third ($1/3$) to one quarter ($1/4$) of its length away from the support wall or beam,
- when working at heights greater than 3 metres above ground level, a second worker should secure the base of the ladder, or it should be securely lashed,
- always face the ladder when ascending or descending, otherwise balance is easily lost,
- never lean beyond arm reach, otherwise balance is easily lost.



NOTE: SHOWN FOR DRIVING ON THE RIGHT

PART A - BRIDGES

4.3 TEMPORARY SIGNPOSTING

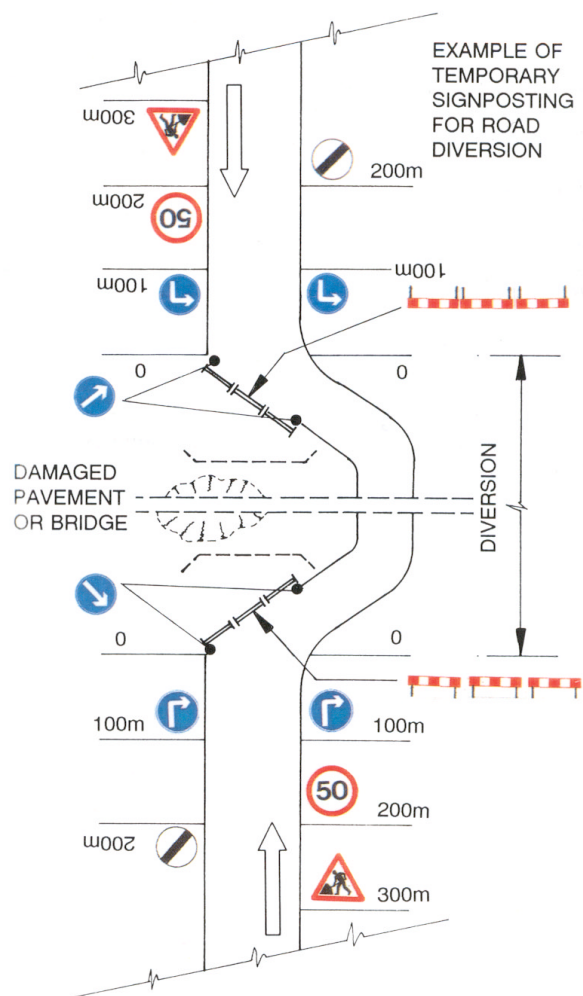
Before work starts, warning signs, barriers and cones must be placed around the work area on the bridge.

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

Signs must be placed in the following order:

- **"Men Working"** signs should be placed **300 metres** in front of the work area.
- **"Road Narrows" and "No Overtaking"** signs should be placed **200 metres** in front of the work area.
- **"Speed Limit"** signs should be placed **100 metres** in front of the work area.
- **Barriers** should be placed at each end of the work area.
- **Cones** should be placed in a taper at the approaches to the work area and at a maximum spacing of **10 metres** along the middle of the road next to the work area.
- **"End of Restriction"** signs should be placed **50 metres** beyond the work area.

Any vehicle or equipment being used for the works must be parked within the coned area.



NOTE: SHOWN FOR DRIVING ON THE RIGHT

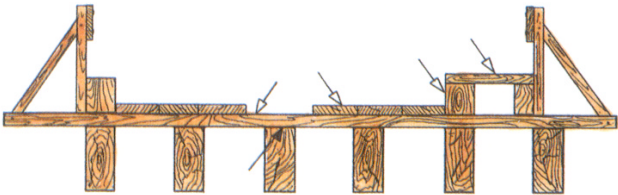
PART A - BRIDGES

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

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

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

- If it is necessary to close the bridge for repair works, a diversion should be arranged and additional barriers and signs will be required as shown.

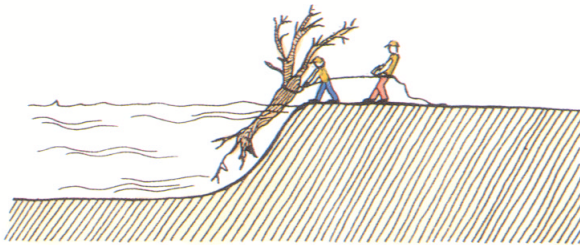
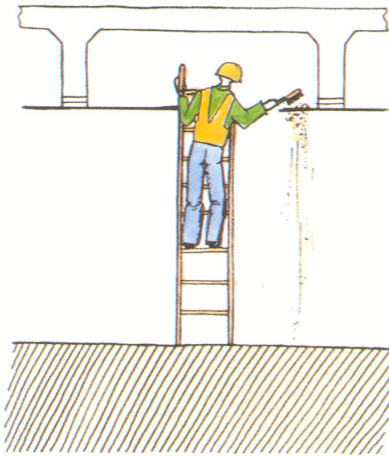
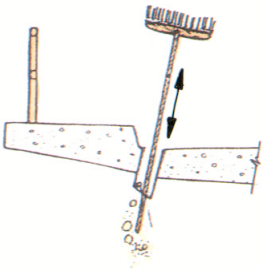


PART A - BRIDGES

4.4 EXECUTION OF THE WORK

The most frequent activities of the bridge maintenance crew will be the routine "cleaning and clearing".

Timber bridges will also require regular visits to repair loose nail and bolt connections, and replace worn or damaged planking.



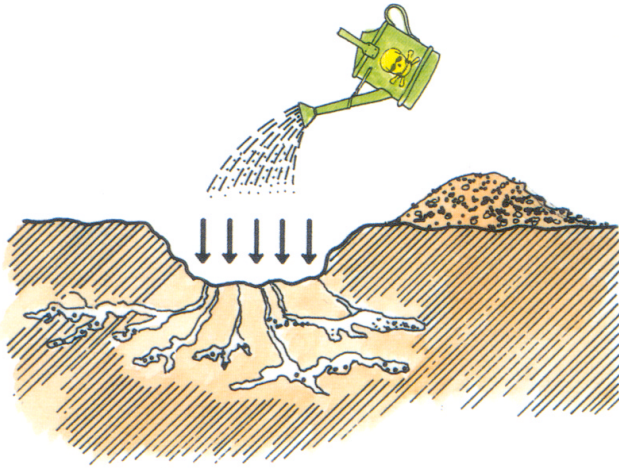
PART A - BRIDGES

Routine* Activities

CLEANING / CLEARING

- **Deck***
Broom the bridge deck and sidewalks clear of all loose soil, dirt, aggregate, debris, and remove these from site.
- **Planking**
Remove all dirt and stones lodged between deck planking.
- **Scuppers***
Clear all drainage* scuppers of dirt and debris so that rainwater can drain freely.
- **Joints, Bearings**
Remove all dirt and debris in joints between beams and abutment walls, and around beam bearings or supports.
- **Flood or Wind Debris, Vegetation**
Remove debris carried by floodwater or wind and lodged at piers and abutments, or at any point under bridge.
Remove growing trees and bushes from area under bridge and directly upstream and downstream, by cutting off near ground level. Dispose of material away from bridge and stream.
Any signs or reflectors on, or at, the bridge should be examined and if necessary washed clean, taking care not to scratch any reflective paint surfaces.

* See List of Terms, Volume 1.



PART A - BRIDGES

■ Termites

Remove termite or "white-ant" tunnels in the vicinity of timber bridges using hoes, shovels or other suitable tools. At the same time soak the ground with an approved effective chemical solutions against wood-destroying insects.

Locate the termite nest if possible. Excavate ground and soak with approved chemicals. Soil poisoning can be effective but may need to be reapplied in areas of severe termite activity.

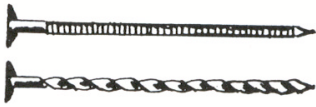
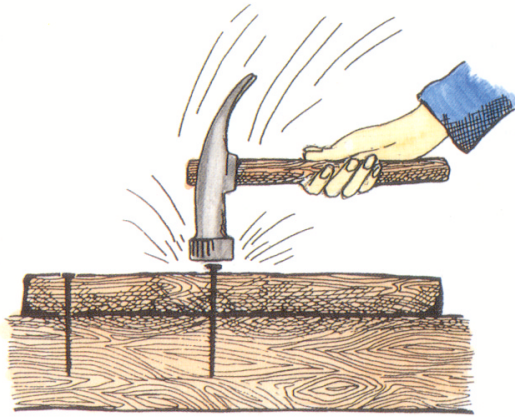
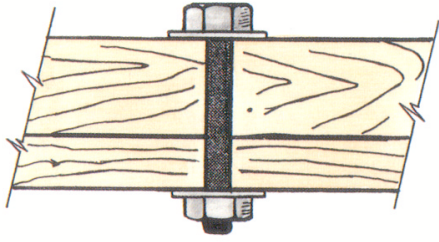
Wood-termites are difficult to exterminate completely. Once a timber bridge or part thereof is attacked, most repair measures are only temporarily effective. Only pressure treated timber, which has been carefully handled after treatment, can effectively resist insect attack.

Where pressure-treated timber is not available, local soil soaking treatment with an approved preservatives and replacement of infested timber are among the limited measures possible.

Infested timber removed from a bridge should be completely burned.

Where termites are common, it is essential that frequent inspections are made.

1 Pentachlorophenol-oil solution can be used, but it is toxic for humans and plants and is also a fire hazard. It should be handled with care and only by workmen who have received instructions regarding proper application. Care must be taken not to contaminate water supplies or watercourses.



PART A - BRIDGES

MINOR REPAIRS (STRUCTURAL)

■ Repair of loose/missing connectors and fixings

The most common timber connectors are **nails** and **bolts**. These work loose under traffic and must be frequently checked. When lost or rusted, they must be replaced.

a) Bolted Joints

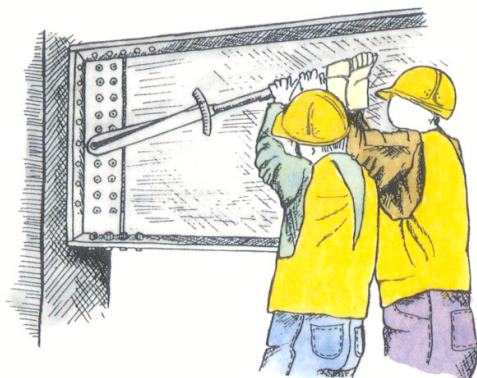
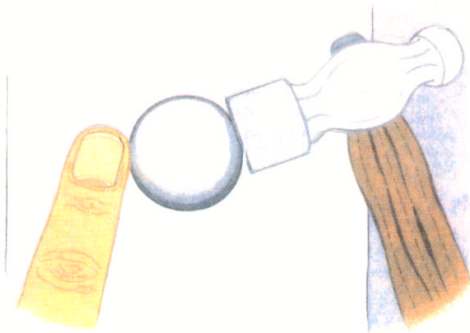
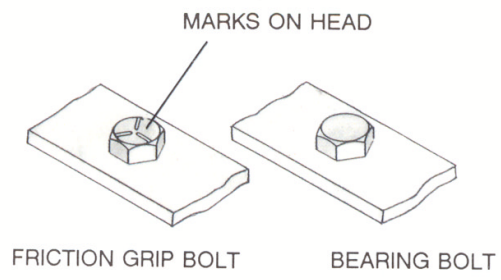
The bolt shaft must fit tightly in the drilled hole. Washers must be thick enough and of ample diameter so that the timber does not crush when the nut is tightened.

b) Nailed Joints

Nails are a frequent source of trouble, especially when the wrong type or length are used. They work loose in timber decks and running boards, can also be drawn out by tyre-suction, and damage vehicle tyres.

Examine running boards under passing traffic for movement. Extract all loose nails. Renail at different points (not in old nail holes), using nails about 3 times the plank thickness. Prebore the holes in the planks if they tend to split when driving the nails. The diameter of the bored hole should be slightly smaller than the nail diameter. For better resistance to nail withdrawal, use nails with irregular shanks, for example:

- annular grooved nail
- spirally grooved nail.

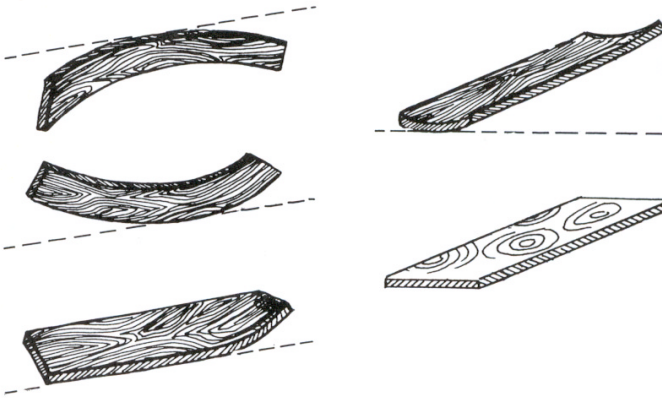
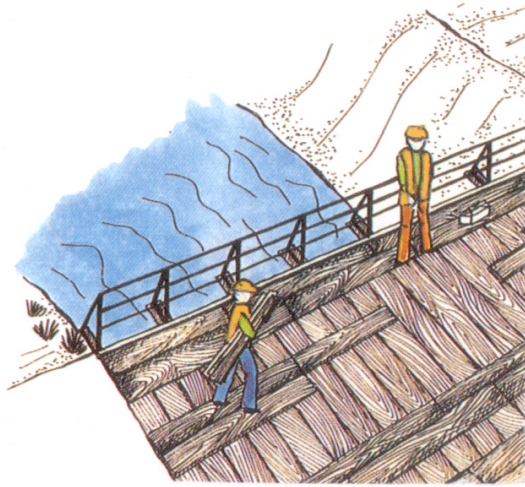


PART A - BRIDGES

On steel bridges friction grip bolts do not normally work loose. Bearing bolts may work loose and should be tightened using a torque wrench" to the settings instructed by the Engineer.

Loose rivets should be heated carefully with an oxyacetylene torch until blood red in colour. They should then be beaten tight using cup shaped dies which fit over the hot rivet and sledge hammers. Care must be taken not to over-heat the rivet (light yellow) or the surrounding steel.

* See List of Terms, Volume I.



PART A - BRIDGES

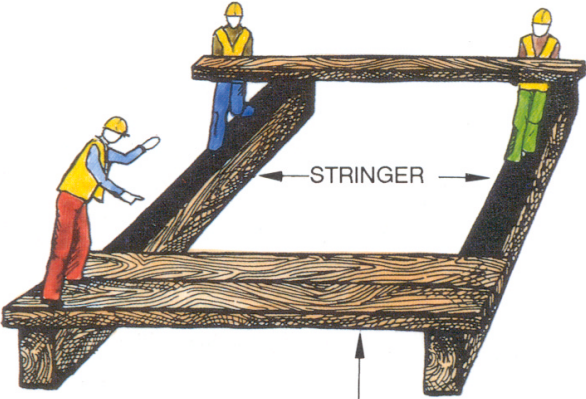
■ Replace Damaged Planks

a) Running

- extract all nails, remove defective planks and clean deck area at contact surfaces,
- use new planks of same dimensions as the planks to be replaced. New planks must be **well seasoned** and treated with a wood preservative. Use about 3 nails for ends of each plank and 2 nails every 25 cms along the plank. Do not drive nails near the edge of the plank; stay at least 3 cm from the edge. All nail heads must be flush with the

Do not use defective timber, for example planks with:

- bows,
- crooks,
- twists,
- cups,
- excessive knots.



← STRINGER →

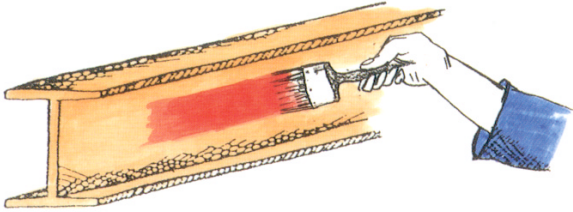
DECK PLANK —

PART A - BRIDGES

b) Deck Planks

- extract nails and lift off running boards and deck planks carefully to avoid damage to the timber stringers*.
- examine top surface of stringers for decay or damage. (Decayed stringers will need to be replaced).
- cover top of stringer with a layer of bituminous felt, place new transverse planking, properly seasoned, and treated with wood preservative, and nail in position. Retain ventilation/drainage gaps between planks.
- when new deck planks are in position, relay old running boards if in good condition. Otherwise replace these with new properly seasoned and treated planks. Nail into position using staggered joints.

**See List of Terms, Volume*



PART A - BRIDGES

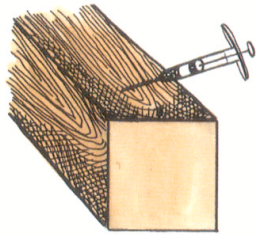
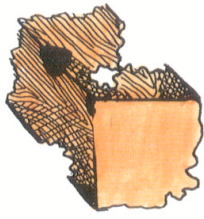
■ Painting

Steelwork painting by the bridge gang is generally restricted to small scale work, for example painting of railings and occasionally, steel beams. Care must be taken to ensure a satisfactory job.

The following steps are recommended:

1. Clean all metal surfaces by removing dirt, dust, rust scale and loose paint. Where possible use a burner (blow torch) and then wire brush the surface to remove all loose particles.
2. Apply priming coat with a brush: brush thoroughly into the steel surface ensuring that the paint covers with an even thin film with no drips. Clean brushes at regular intervals to
3. Allow priming coat to dry thoroughly (24 hours or according to local experience).
4. Apply intermediate coat (using an oil-based, metallic based, synthetic resin or other proven high-quality paint) in the same manner as for the priming coat.
5. Allow the intermediate coat ample time to dry thoroughly.
6. Apply a final coat as in (4). The colour of both the intermediate coat and the final coat should be as bright as possible for better visibility and safety.

For painting of concrete or stone surfaces, see Part B, "Traffic Control Devices".



■ **Wood Preservation**

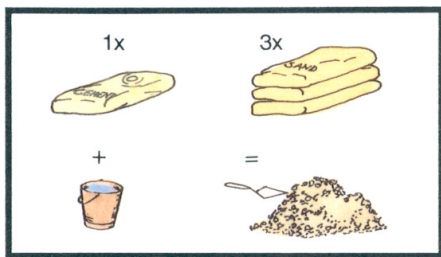
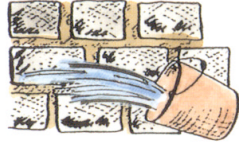
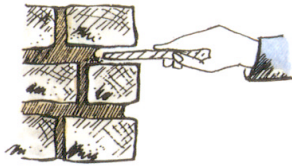
Wood preservation of structural timber can only be thoroughly and reliably achieved by pressure impregnation where the preservative liquid is injected deep into the timber. When pressure treatment of replacement sections cannot be employed, apply a superficial treatment. This method is only of very limited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

A suggested procedure for superficial treatment is as follows, working with protective gloves and clothing:

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

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

1 For example: a solution of coal-tar creosote and used motor-oil.



■ **Pointing Masonry**

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

- clean and rake out defective joints of weak mortar, soil and vegetation using compressed air or a water spray, hammer and chisel,
- at locations where the joint has to be completely renewed, the stone or brick should be eased out of place temporarily until a new mortar bed is placed,
- dampen the joint surfaces where fresh mortar has to be applied,
- mix a mortar of cement and sand as required (1 cement: 3 sand) and add **only enough** water to permit mortar to be applied,
- apply fresh mortar to joint, filling all space available, compacting with a suitable wooden yammer. Do not use mortar which has fallen on the ground,
- smooth joints with a suitable tool (a piece of rubber or plastic water hose, or bent reinforcing steel),
- the final mortar surface should be inset slightly from the stone/brick surface to achieve a tidy finish,
- in dry weather conditions, mortar can dry out quickly. Prevent this by sprinkling water on joints after the mortar has set and until mortar has completely hardened. Alternatively cover the work area with wet jute sacks or similar,
- clean visible stone or brick surfaces which have been stained by mortar or cement-water in the process of the work so that the finished work will present a neat appearance,
- **remove surplus materials and leave the site in a clean and tidy condition.**



PART A - BRIDGES

MINOR REPAIRS (SAFETY)

■ **Repair barriers and safety features**

Steel safety barriers, railing or parapets are damaged by vehicles from time to time. They must be repaired to continue to provide their safety function.

The damaged section should be dismantled by unbolting or using cutting equipment if necessary.

A new section should be bolted or welded in place and painted if necessary.

If new sections are not available the damaged parts should be repaired in the workshops and reinstalled.

Damaged signs should be repaired as described in Part B (Traffic Control Devices).



PART A - BRIDGES

Periodic* Activities

MAJOR REPAIRS

This Part deals with only the more straightforward repairs. Complicated major defects (discussed on Page IV - 15) require specific detailed instructions, drawings and specifications to be prepared and are not covered by this Handbook.

■ Random Stone Filling

This activity may be required as an emergency measure to fill eroding riverbank areas under water. It is limited to local repair of small bank areas and where the water is relatively shallow (up to 1.5 metres).

If possible prepare an approximately level bedding area where the stone blocks are to be dumped.

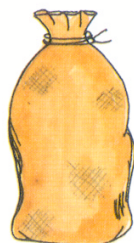
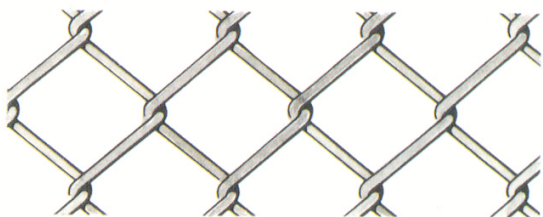
OPTION 1: USING LARGE STONES

Place the largest stones in the lower layers.

Build up layers ensuring a stable construction.

Continue placing until stream bank regains a satisfactory shape.

** See List of Terms, Volume I.*



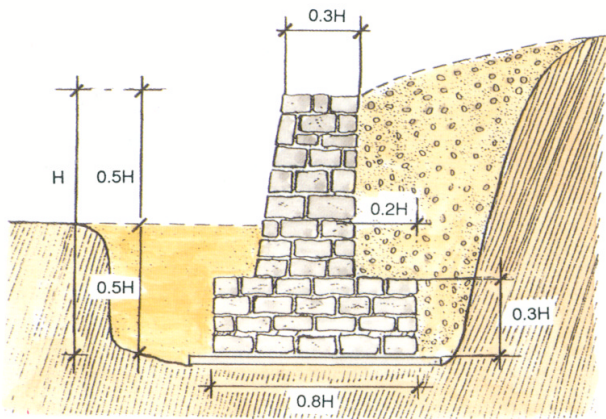
PART A - BRIDGES

OPTION 2: IN STRONG CURRENTS

Where there is a danger that the stones will be washed away by strong currents, small wire baskets should be made from chain link fencing or woven wire. These should be filled with the stones and placed in layers. The completed baskets will be stronger if they are also woven together.

OPTION 3: USING SMALL STONES/SAND/SOIL

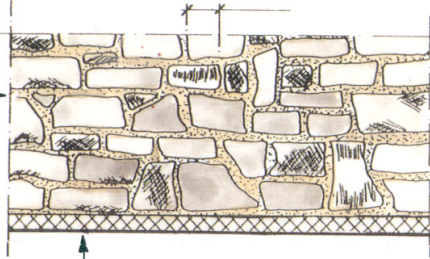
Where stone is not available, use jute or strong plastic sacks filled about 1/2 to 2/3 full and firmly tied. Place in position as above.



JOINTS 1 TO 4cm

BOND MIN. $\frac{1}{4}$ OF STONE LENGTH

BLINDING



■ **Retaining Wall**

This can be constructed to protect the toe of an embankment or short lengths of stream-bank. Construct when the river bed is dry and when the free height of wall (0.5 H) is limited to a maximum of about 1.5 metres. If the river bed does not dry out a coffer dam* will need to be constructed to allow dry working.

Determine beforehand that the soil is firm enough at the foundation level by digging holes to the estimated level. The Engineer should inspect and approve the excavation before any work is started.

Excavate foundation according to the plans.

Prepare level foundation bed and compact until bed is firm.

Spread 5 cm of mortar (1 cement : 6 sand) or concrete blinding* (1 cement : 4 sand : 8 stone) as a clean working area and let this set hard.

Use (1 cement : 4 sand) mortar for all masonry work. Use a gauge box to measure the mix proportions. Add only enough water to make the mix workable.

Mix only the quantity of mortar that can be used within one hour.

* See List of Terms, Volume 1.



Figure 1: A photograph of a steep, light-colored stone or concrete retaining wall on a hillside, with a paved road running along its base.

Figure 2: A photograph of a steep, light-colored stone or concrete retaining wall on a hillside, with a paved road running along its base.



Figure 3: A photograph of a retaining wall constructed from dark, irregular stones, topped with a row of reddish-brown bricks. A paved road is visible at the bottom left.

PART A - BRIDGES

Place largest stones lying flat in the lower layers on a mortar bed and fill all spaces with small stone and mortar. Each stone must be seated firmly, but no stone should touch another. Mortar joints should be 1 to 4 cms thick.

Place each succeeding layer on a bed of mortar, filling the spaces as before.

Build the ends of the walls first to set the correct size and profile. On long walls split the job into bays of 5 to 10 metres length for ease of construction.

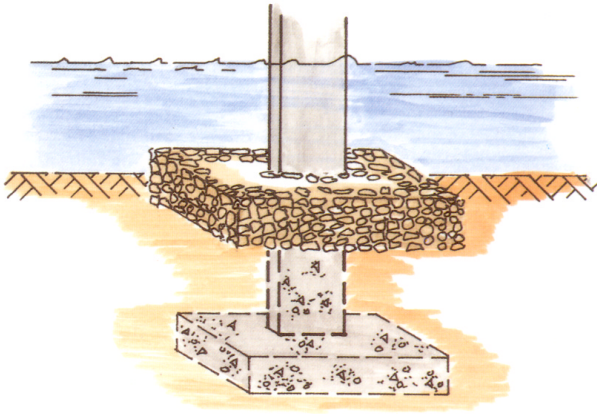
Use a stringline and spirit level to check the line and level of each layer.

When the foundation is complete, backfill around it in layers, tamping each soil layer until no further compaction is attained.

Complete the wall to full height. Where weep holes are specified construct them with a filter plug to prevent fine material being washed through (lean concrete will be suitable).

Cover completed work with wet sacking regardless of work progress to prevent mortar from drying out too quickly.

Backfill in layers behind the wall using gravel, broken stone, quarry waste or other free draining material.



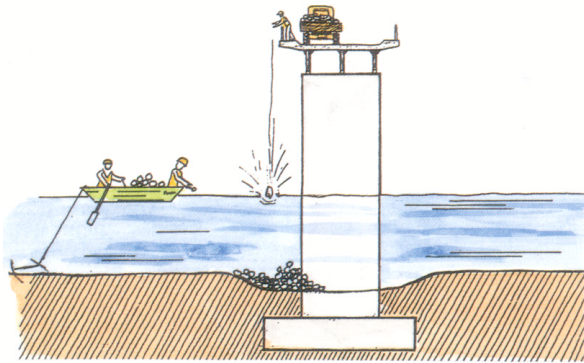
PART A - BRIDGES

■ **Riverbed Scour* Apron**

Loss of riverbed material by fast flowing water at piers, abutments and wing walls is best identified and repaired at low water level or when the river bed is dry.

The scoured area should be refilled with rock using stone pieces of 10 to 30 kg weight, or heavier. The decision on stone size must be made, taking into account what is locally available.

** See List of Terms, Volume I.*



PART A - BRIDGES

IF SCOUR AREA DRIES OUT:

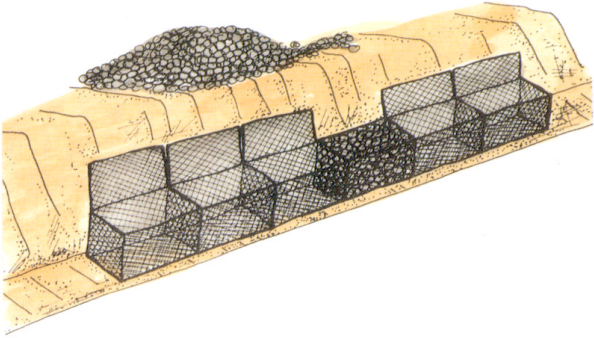
1. Stake out the area around the pier or wall where scour has occurred.
2. Excavate to estimated lowest scour level.
3. Place riprap stone in layers in the excavation, starting with the smaller size stone in the lowest layer.
4. Fill spaces between stones with smaller size stone.
5. Continue work layer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

IF SCoured AREA IS SUBMERGED:

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

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

* See List of Terms, Volume I.



PART A - BRIDGES

■ **Gabions***

Where available, gabions can also be used as stream-bank protection structures. They are usually made of zinc coated steel baskets, although may also be made from welded mesh sheets, galvanised chainlink fencing and woven wire depending on the circumstances. The baskets are hand-filled with rock and stones between 12 and 30 cm size.

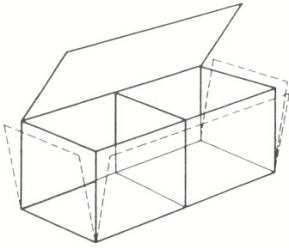
In this way they attain great stability, but will allow minor settlement.

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

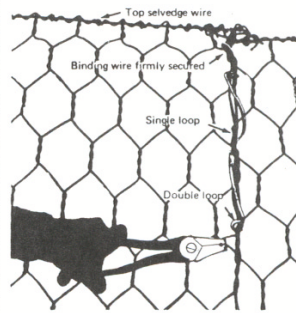
Foundations should be excavated level and cleaned as for a conventional structure, with any unsuitable material removed and replaced with good soil, stone or gravel, and compacted. The baskets should be erected in their final position.

* See *List of Terms, Volume*

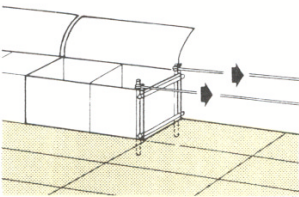
1. ASSEMBLE CAGE



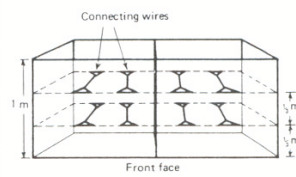
2. WEAVE BOXES SECURELY TOGETHER



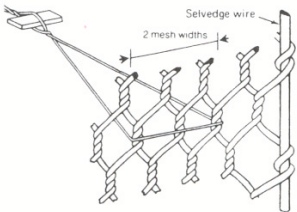
3. STAKE AND STRETCH CAGES TO REQUIRED SHAPE



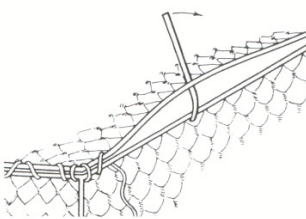
4. INTERMEDIATE BRACING



5. WINDLASS BRACING



6. CLOSE AND SECURE LID



PART A - BRIDGES

Cages should be woven together using 3 mm binding wire securing all edges every 15 cms with a double loop. The binding wire should be drawn tight with a pair of heavy duty pliers and secured with multiple twists (**1** and **2**). The centre gabion only should be filled initially to act as an anchorage.

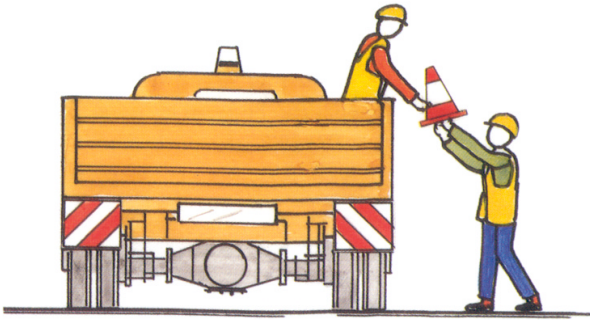
The connected baskets should be stretched and staked with wires and pegs to achieve the required shape (**3**).

Filling should be carried out by hand using hard durable stones not larger than 250 mm and not smaller than the size of the mesh. The best size range is 125 to 200 mm. The stones should be tightly packed with a minimum of voids.

Boxes of 1 metre height should be filled to 1/3 height. Horizontal bracing wires should then be fitted and tensioned with a windlass to keep the vertical faces even and free of bulges (**4** and **5**). Further bracing should be fixed after filling to 2/3 height. 500 mm height boxes should be braced at mid height only. 250/330 mm deep gabions do not require internal bracing.

The stones should be carefully packed to about 3 to 5 cms above the top of the box walls to allow for settlement. Smaller material can be used to fill the voids on the top face, but excessive use of small stones should be avoided.

The lids are then closed and stretched tightly over the stones, (carefully) using crowbars if necessary (**6**). The corners should be temporarily secured to ensure that the mesh covers the whole area of the box. The lid should then be securely woven to the tops of the walls removing stones if necessary to prevent the lid from being overstretched.



PART A - BRIDGES

4.5 COMPLETION AND REMOVAL OF TEMPORARY SIGNS

- Clean tools.
- Load all tools, equipment and surplus materials onto the truck. The carriageway" sidewalks and approaches of the bridge **must be left in a tidy and clean condition.**
- Check the site under the bridge, that no item has been overlooked or forgotten, or that no heaps of material or spoil have been left.
- Collect all cones, warning signs, flags and barriers.
- Clean them and load them onto the truck.
- Proceed to the next site or back to the depot.

* See List of Terms, Volume 1.

TYPICAL WORK REPORT
BRIDGE MAINTENANCE

Work Report No: Date:

District: Gang:

Zone: Road No.:

Section: from km to km

Bridge No:

Location:

WORK ACHIEVED:

.....

.....

MANPOWER USED:

Name Grade Hours worked

Name Grade Hours worked

Name Grade Hours worked

EQUIPMENT USED: DIESEL USED:

Hrs litres

Hrs litres

MATERIALS USED:

.....

COMMENTS:

Foreman:

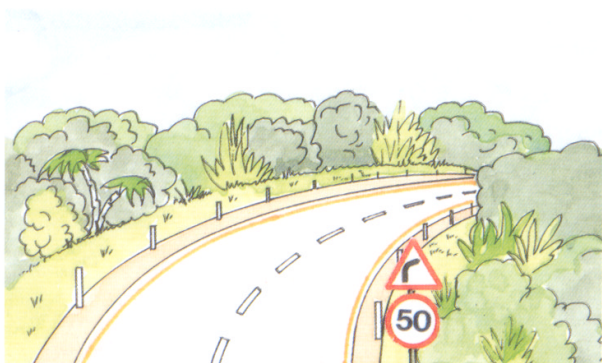
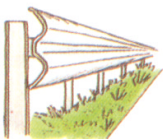
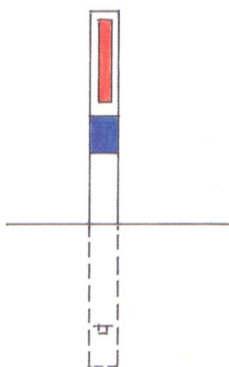
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4.6 WORK REPORT

- The report must be filled in **each day**, detailing:
 - the work carried out,
 - the resources used.

Part B

TRAFFIC CONTROL DEVICES



PART B - TRAFFIC CONTROL DEVICES

1. THE TASK

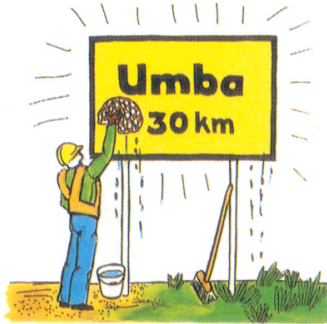
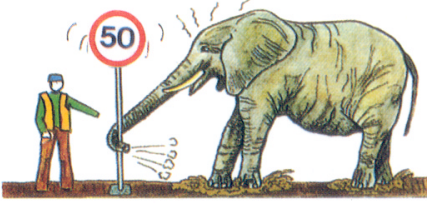
The task is to carry out all necessary:

- **Routine*** maintenance activities and
- **Periodic*** maintenance activities

of traffic control devices, for example

- Signs, reflectors, guide-posts
- Kilometre-stones
- Guardrails and
- Pavement markings.

* See *List of Terms, Volume*



PART B - TRAFFIC CONTROL DEVICES

1.1 OBJECTIVE

- Traffic control devices must always serve their intended function:
 - giving orders,
 - giving warning,
 - reducing hazards.
- Traffic control devices must always be clean and visible.
- Traffic control devices must be correctly located.
- Traffic control devices must be securely mounted or fixed.

They should be kept in a condition similar to that at original installation.

1.2 ACTIVITIES

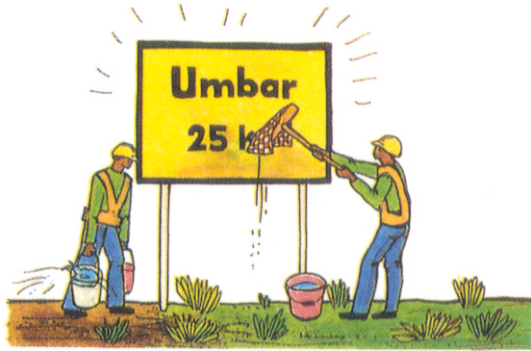
Routine* Activities

- Cleaning
- Repainting
- Repairing on the site
- Repairing in the workshop
- Vegetation control

Periodic* Activities.

- Replacing guardrails
- Pavement marking
- Replacing sign
- Repairing or Relocating kilometre-stone

* See List of Terms, Volume I.



2. DEFECTS

Defects in traffic control devices should be detected early and repaired promptly. Neglected repair can lead to traffic accidents.

2.1 LIST OF DEFECTS

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

Routine Activities

■ Defect

The road sign is dirty and/or dusty.

Main Cause

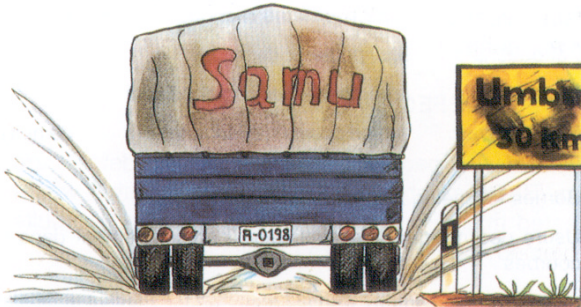
Traffic raises dust clouds during dry weather or splashes mud during wet weather onto signs and posts.

Development if neglected

- the sign does not serve intended use,
- the danger of rusting of a steel plate sign increases,
- increased danger of accidents.

Remedy

Cleaning



PART B - TRAFFIC CONTROL DEVICES

■ Defect

The painted surface is faded or flaking off

- a) steel posts or sign plates
- b) timber guide-post and signs
- c) concrete kilometre-stone.

Main Cause

Weathering, ageing.

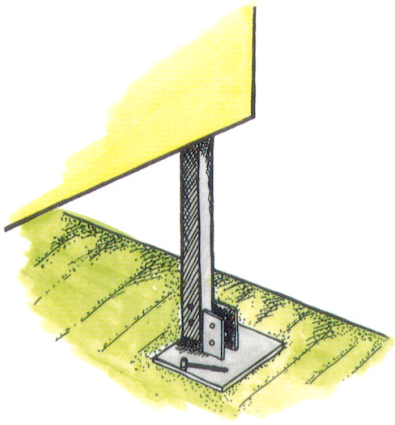
Development if neglected

- the sign does not serve intended use,
- the danger of rusting of a steel plate sign increases,
- increased danger of accidents.

Remedy

Repainting

- a) steel surface
- b) timber surface
- c) concrete surface.



PART B - TRAFFIC CONTROL DEVICES

■ Defect

- a) bolts have been broken or removed from a sign support
- b) a timber or steel post is broken
- c) the sign is demolished or severely damaged.

Main Causes

- a) vandalism/accident
- b,c) accident.

Development if neglected

Danger to traffic and persons.

Remedy

- a,b) repairing on the site
- c) repairing in the workshop.

■ Defect

The road signs and guide-posts are not visible.

Main Cause

Vegetation has grown up around the signs and reduced visibility.

Development if neglected

Increased danger of accidents to road users.

Remedy

Vegetation control, see Part C, "Roadside Areas" in Volume I.



PART B - TRAFFIC CONTROL DEVICES

Periodic Activities

■ Defect

Guardrail and post are damaged.

Main Causes

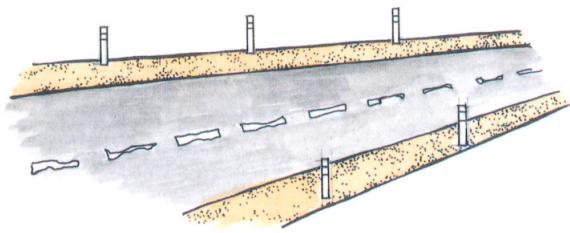
Vehicle accident
Insect attack (wooden posts).

Development if neglected

The guardrail cannot effectively hold back a vehicle at the damaged area and therefore does not serve its intended purpose.

Remedy

Replacing guardrails and/or posts.



PART B - TRAFFIC CONTROL DEVICES

■ Defect

The pavement line-markings are worn.

Main Cause

Traffic action and weathering.

Development, if neglected

The pavement line-markings will in time wear completely away and cease to be of any guidance to road users. There is an increased danger of accidents particularly on curves and narrow highways at night.

Remedy

Pavement marking.

■ Defect

- a) the sign is illegible (or missing)
- b) the sign is damaged beyond repair.

Main Causes

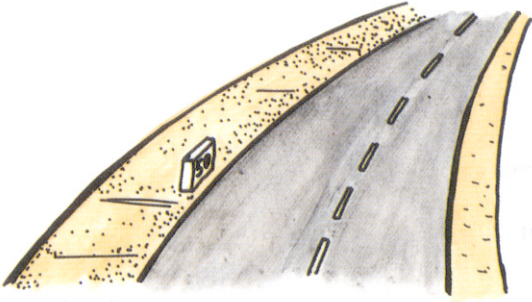
- a) weathering, corrosion or vandalism
- b) traffic accident, vandalism, brush fire.

Development, if neglected

The road users lose the benefit of important traffic signs and the danger of accidents is increased.

Remedy

Replacing sign.



PART B - TRAFFIC CONTROL DEVICES

■ Defect

- a) the kilometre-stone is damaged
- b) the kilometre-stone is too close to the carriageway*
- c) the distance shown on the kilometre-stone is wrong.

Main Causes

- a) accident
- b) the stone has been positioned incorrectly or the carriageway has been widened
- c) the road has been reconstructed thereby shortening overall distances.

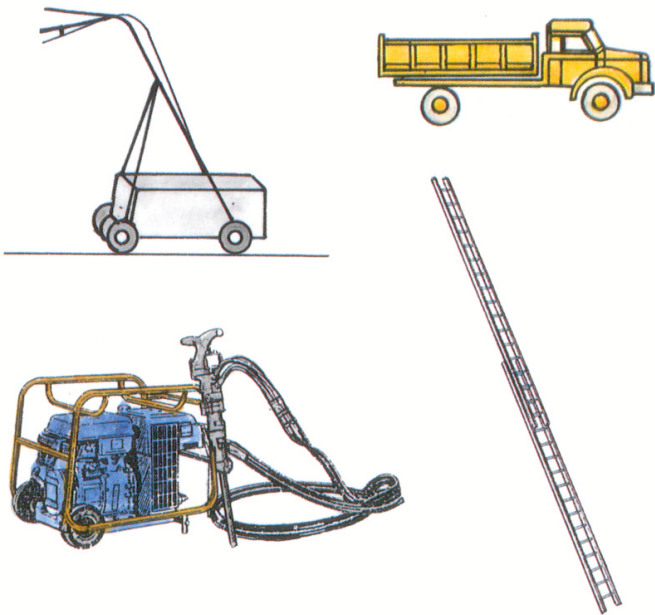
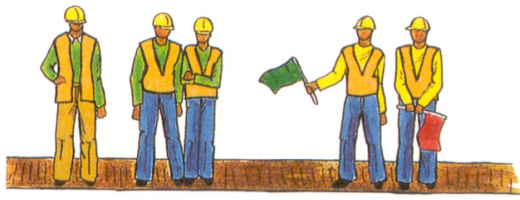
Development, if neglected

- a,b) the kilometre-stone becomes a traffic hazard to vehicles which may have to drive onto the shoulder*
- c) the distance shown is greater than it should be. The kilometre-stone is not serving its intended purpose for road users and maintenance personnel.

Remedy

Relocating or replacing kilometre-stone.

* See List of Terms, Volume



3. RESOURCES

3.1 PERSONNEL

■ Supervisors

- 1 foreman/overseer.

■ Plant Operators and Drivers

- 1 truck driver.

■ Workforce

- 2 labourers,
- 1 carpenter) part-time,
- 1 mason) part-time
- 2 (or more) painters,
- 1 to 2 traffic controllers.

3.2 PLANT AND TOOLS

- 1 flat-bed truck
- 1 ladder.

Special equipment may sometimes be required, for example:

- compressor and pneumatic hammer (to remove foundations of signs or kilometre-stones during replacement, or for similar work),
- \compressed air-driven grinding tool for removing rust,
- line-marking machine.



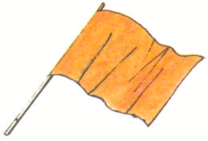
PART B - TRAFFIC CONTROL DEVICES

3.2 PLANT AND TOOLS Continued

- assorted hand tools (spanners, screw-drivers, hammers etc.),
- cleaning utensils, buckets,
- set of paint brushes of various sizes, and paint rollers,
- spade, shovel,
- hoe/mattock, axe,
- pickaxe, steel wire brushes,
- saws, chisels, spirit level,
- hand rammer,
- brace and drill bits,
- folding rule (2 metre),
- stencils for pavement markings,
- tape measure (30 metre),
- string,
- 2 grass slashers/sickles/scythes,
- 2 bush knives,
- 2 drums (200 litre) as water containers,
- brooms,
- hand auger (for post holes).

3.3 MATERIALS

- assorted replacement signs, posts, and fixing brackets,
- assorted bolts, nuts, screws,
- timber preservative, rust treatment paint/primer,
- paints,
- solvents, sand paper,
- cement, sand, aggregate,
- detergent, cleaning cloths,
- self-adhesive tape,
- water, kerosene (for cleaning signs),
- guardrail sections, posts and fittings.



2



2



2



2



2



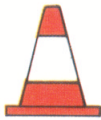
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2



PART B - TRAFFIC CONTROL DEVICES

3.4 SIGNS AND SAFETY EQUIPMENT

Pavement marking is a potentially hazardous activity and it is important that the following items are provided:

■ Traffic Signs

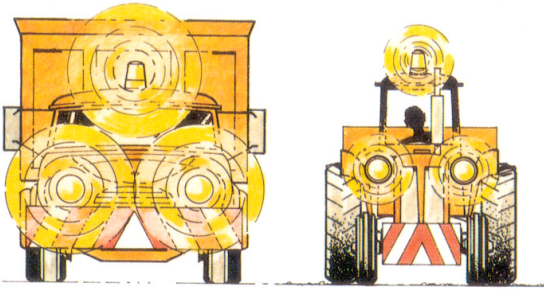
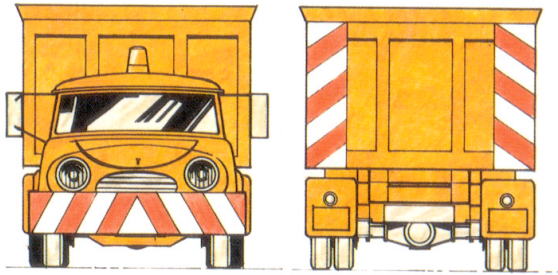
- 2 Yellow/orange flags,
- 2 "Keep Left/Right" arrows,
- 2 "Speed Limit" signs (50 km/hr),
- 2 "Speed Limit" signs (80 km/hr),
- 2 "Men Working" signs,
- 2 "No Overtaking" signs,
- 2 "Line Painting Ahead" signs,
- 2 "End of Restriction" signs.

■ Traffic Cones

As many as are required to protect the freshly painted markings (at least 20).

When maintenance work on roadside signs or guardrails requires that part of the carriageway* is used, the signs and safety equipment detailed on Page **IV** - 35 should be used.

* See *List of Terms, Volume 1*.



PART B - TRAFFIC CONTROL DEVICES

■ Clothing

Yellow or orange coloured safety vests or safety harnesses to be worn by the supervisor and all of the work force.

- 1 lightweight safety helmet should be provided for each supervisor and workman.
- 1 first aid kit.

■ Vehicles

All vehicles and equipment working on the roadway should be painted yellow or orange and should carry red and white striped marker boards front and rear.

■ Lights

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 of equipment should carry yellow or orange flags.

TYPICAL WORKSHEET

TRAFFIC CONTROL DEVICES

Worksheet No.: Date:

District:

Zone: Gang:

Road No.: from to

Location(s):

Work to be carried out:

.....

.....

.....

.....

.....

.....

Work to be completed by: (Date)

Signed:

(Engineer)/(Technical Assistant)

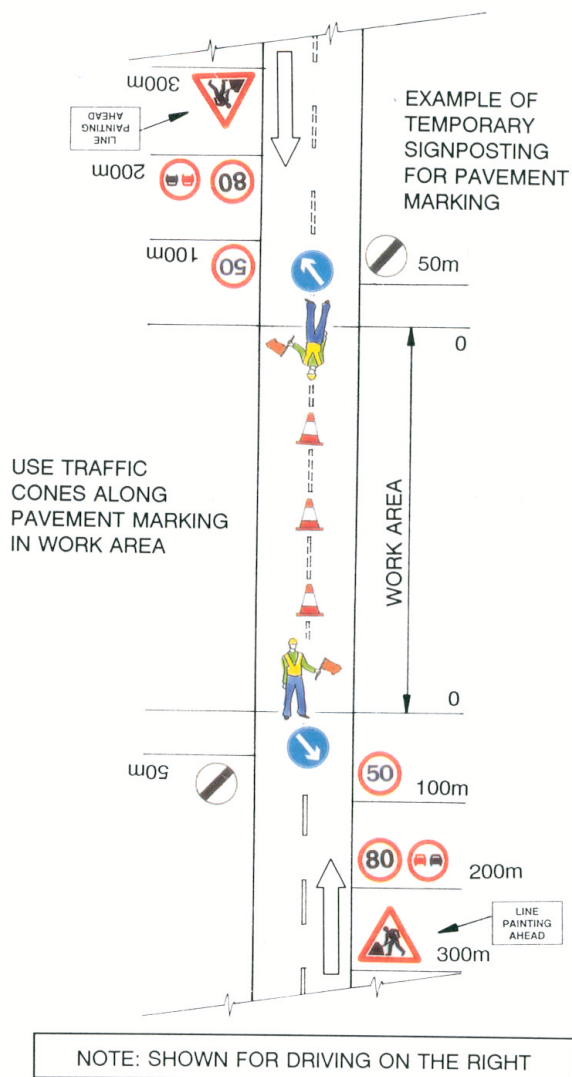
4. MAINTENANCE METHOD

4.1 PRELIMINARY TASKS

- **The worksheet** will indicate the locations and type of work to be carried out and the time, equipment and personnel required for the job.

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

- The **manpower** required for the specified work must be arranged.
- The **truck** must be fuelled, checked mechanically and have water and oil levels checked.
- The **equipment, handtools and materials** required must be organised.
- **Traffic signs, barriers and cones** must be obtained and loaded onto the truck.



PART B - TRAFFIC CONTROL DEVICES

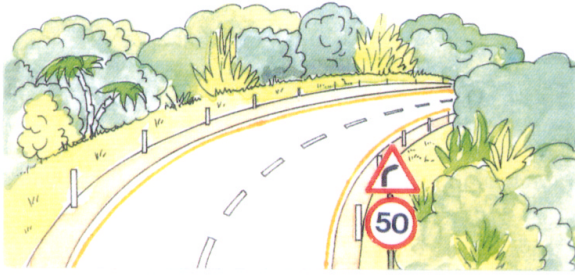
4.2 TEMPORARY SIGNPOSTING

When work is necessary on the carriageway or shoulder, warning signs, barriers and cones must be placed around the work area before work starts. For centre line pavement markings the **Signs** must be placed in the following order:

- **"Men Working" and "Line Painting Ahead"** signs should be placed **300 metres** in front of the work area.
- **"80 km/hr Speed Limit" and "No Overtaking"** signs should be placed **200 metres** in front of the work area.
- **"50 km/hr Speed Limit"** signs should be placed **100 metres** in front of the work area.
- **"Keep Left/Right"** arrows should be placed at the start of the work.
- **Cones** should be placed along the work area and at a maximum spacing of **10 metres** along the middle of the road to protect the workforce and freshly painted markings.
- **"End of Restriction"** signs should be placed **50 metres** beyond the work area.

Any vehicle or equipment being used for the works must be parked off the carriageway.

For edge markings and any other work on the carriageway or shoulder, where the carriageway plus shoulders is less than 7.5 metres wide, the signs should be provided as shown on Page IV - 35 with additional cones as required.



4.3 EXECUTION OF THE WORK

Most of the activities can be carried out with hand tools. Where specialised work is required, workshop and paintshop facilities will be necessary.

Do not leave any unattended obstructions on the carriageway at night.

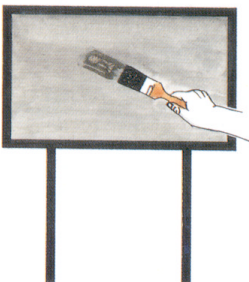
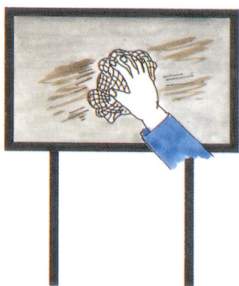
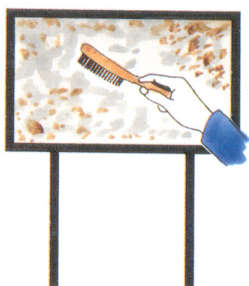
Vegetation control is described in Volume I, Part C.

Routine Activities

■ Cleaning

This activity is limited to cleaning signs, reflectors, guide-posts and kilometre-stones in order to retain their effectiveness.

- clean signs, reflectors, guide-posts etc. at least twice a year or more often if local conditions require,
- wash the surface using a cloth, water and detergent solution. Take care not to scratch the surface or damage a reflective paint surface,
- after washing, remove all traces of detergent with a cloth, and soft brush, and rinse with water,
- clean the back of the sign at the same time using water and a cloth. Use a hand brush to remove dirt from corners and fittings,
- where signs or reflectors are contaminated with bitumen or oil streaks, use kerosene for cleaning and then wash down with water.



PART B - TRAFFIC CONTROL DEVICES

■ Repainting

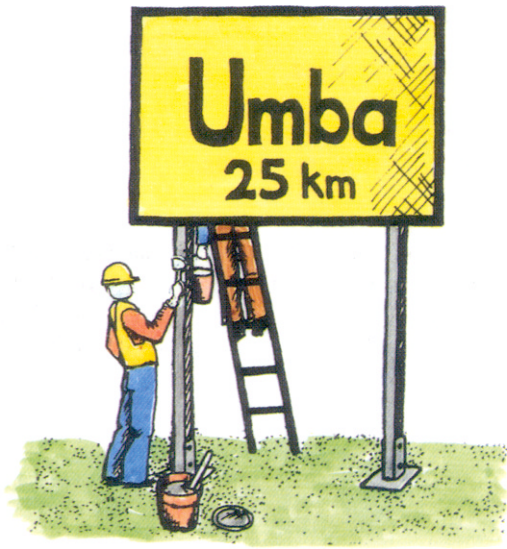
This activity involves painting or repainting:

- supporting posts for signs,
- rear panels of signs,
- kilometre-stones,
- guide-posts, culvert marker posts.

Do not paint the front face of a sign. This work is best done in the paintshop. A reflective material surface should never be touched-up with paint as it will immediately lose its effectiveness over the repainted area.

In general:

- surfaces to be painted are to be cleaned free of rust, dirt and all other contamination,
- use only clean soft brushes or rollers,
- painting should only be carried out during dry weather. Do not paint on a wet surface or during rain,
- paints must be thoroughly mixed before application. If thinners are to be used, follow manufacturer's instructions, take precautions against fire,
- when reflectors are set into or mounted on surfaces to be painted, cover these completely with paper or tape for protection during painting.



PART B - TRAFFIC CONTROL DEVICES

a) Repainting Steel Surfaces

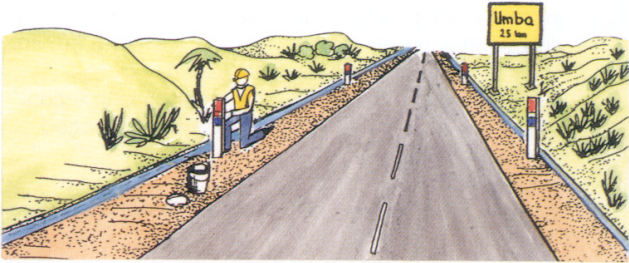
(Sign supports, rear panels of signs etc.)

- if surface paint is flaky use a wire brush to remove all loose paint and rust,
- clean surface area to be repainted using water and cloth, and then allow surface to dry thoroughly,
- use sandpaper on existing paint to provide a key for the new paint. Brush the surface clean,
- as soon as the surface is dry, apply a prime coat` evenly to all areas where old paint is damaged or removed. Allow to dry,
- apply the finishing coat
- replace lids firmly on paint cans and thoroughly clean brushes and rollers.

b) Repainting Timber Surfaces

- remove all loose paint using a wire brush if necessary,
- clean dust or dirt from surface using a cloth and water. Allow surface to dry,
- apply a prime coat* evenly to all areas where the old paint is damaged or removed. Allow the prime coat to dry,
- apply one finishing coat* of specified colour,
- reseal paint cans airtight, and thoroughly clean brushes and rollers.

**Use only paints of approved type and colour.*



PART B -TRAFFIC CONTROL DEVICES

c) Repainting Concrete or Stone Surfaces

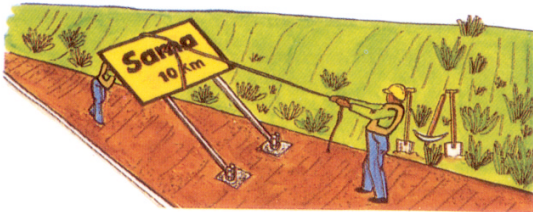
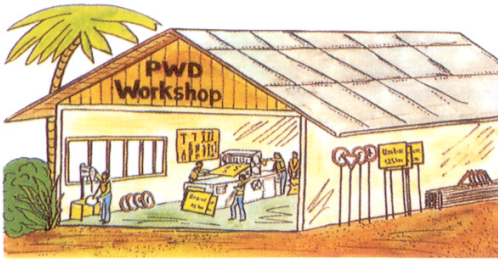
- wash thoroughly all dirt, soil, dust etc. from surfaces and allow to dry,
- apply one coat of water-based, cement or latex paint of specified colour to visible surfaces,
- numbers or letters can be painted with the same type of paint of a specified contrasting colour.

■ Repainting on the site

- correct wrongly facing or tilted sign. Move post to upright position. Check plumb and orientation. Recompact soil backfill. Backfill around base of post with concrete if necessary to improve stability, using temporary supports if required until concrete sets,
- replace bolts and nuts. If necessary apply a drop of oil to the bolt or screw before tightening with wrench or screw-driver. Be sure that the drilled holes are well aligned, and that the bolt thread will not be damaged when inserting,
- replace timber support for signs. Use temporary strut to support sign and remove damaged post from its foundation; clean out foundation of loose soil. Remove any traces of insect infested timber. Replace post with similar post treated with wood preservative and attach to sign. Backfill and compact with hand rammer.

Other minor repairs are:

- setting posts deeper for extra sign stability. The depth of buried post should be at least 1/4 the length of the post where no concrete bases are provided. Signs must be fixed at the specified height.



PART B - TRAFFIC CONTROL DEVICES

■ Repairing in the workshop

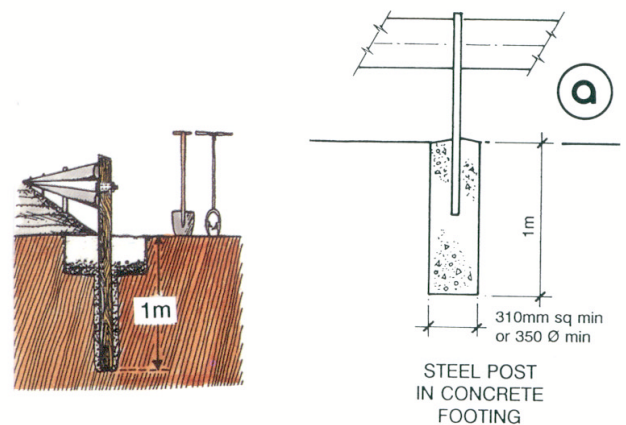
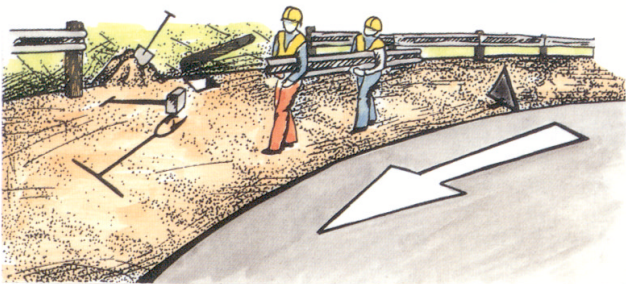
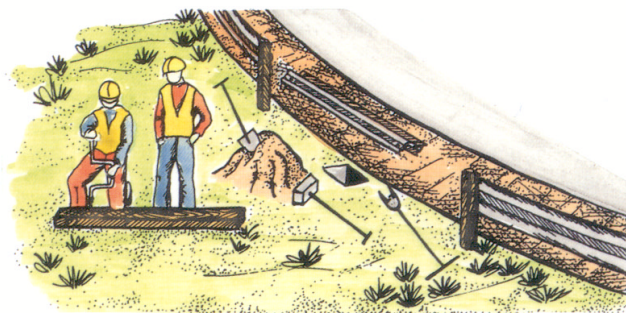
Signs which cannot be repaired on the site must be repaired in the workshop or paintshop.

- dismantle the sign from its posts) carefully retaining all nuts, bolts or screws. Transport it to the workshop,
- when the sign has been repaired, transport it to the site; reinstall it in its original location. Be sure all bolts, nuts and screws are replaced and properly tightened.

Do not remove signs which have legal status, e.g. "STOP" signs. These **MUST** be replaced,
(See Page **IV** - 127).

■ Vegetation Control

Refer to Volume I, Part C.



PART B - TRAFFIC CONTROL DEVICES

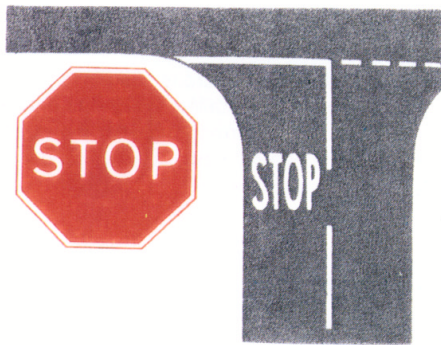
Periodic Activities

■ Replacing Guardrails

Unbolt damaged guardrail panels and posts and remove. Retain all undamaged bolts and nuts.

- if the timber or steel post is damaged, it must be extracted and replaced,
- new timber posts must be of the correct length, pressure treated if possible, and the top sawn at an angle to allow rainwater to run off. Drill the holes for bolts,
- excavate the post hole wide enough to allow use of the tamper to compact soil around the post. Alternatively, an excavation can be hand bored using a hand-auger for the lower half of the excavation,
- place the post in the excavation, check position, height and alignment. The post must be kept vertical and in alignment during backfilling,
- place the backfill in layers not exceeding 10 cm loose soil. Compact the loose soil with a hand rammer, adding water if necessary until no further compaction* is attainable. Repeat until the soil backfill is level with the ground surface,
- where steel posts are used, they should be cast into a concrete footing as shown (a), allow the concrete to set,
- assemble the new guardrails, taking care that the section overlaps are installed exactly as before. (The joint overlaps must correspond with the direction of the traffic in the nearest lane*),
- tighten all bolts and nuts.

*See List of Terms, Volume 1.



PART B - TRAFFIC CONTROL DEVICES

■ Pavement Marking

Pavement marking is usually limited to repainting existing worn centre lines, overtaking guidelines and shoulder edge lines, in order to restore them to their intended colour and outline. Markings also have to be renewed after resealing, overlay or some patching operations. Renewal sections should be marked out with chalk by the road surveyor.

- no painting work should start until all warning and speed reduction signs and the flagmen are in position as indicated in the temporary signposting plan (Page **IV** - 109). Ensure that the workforce can work safely,
- the road surface must be dry,
- clean existing road markings where required using a stiff brush. No dirt, dust or other contamination should be left on the surface to be painted,
- **apply the paint sparingly** after thoroughly mixing and adjusting the stencil to the line edges. Thick paint lines tend to crack on drying. Paint only within the limits of the existing markings, otherwise the edges will look ragged. Do not leave open paint cans unattended. If a spill occurs, clean pavement surface immediately,
- the road marking paint should dry in about 10 - 15 minutes (depending on paint type and weather conditions). Do not remove any cones or allow traffic to run over the freshly painted lines before the paint is dry enough for traffic.



Men painting the word "GIVE" on a road.

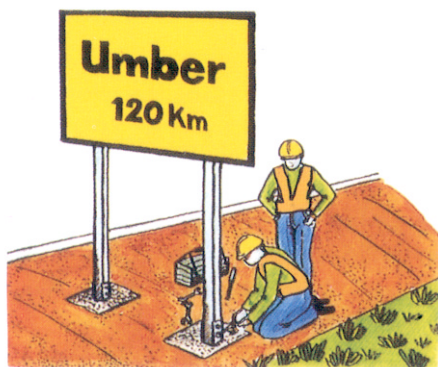


A man operating a white utility vehicle with a red and black chevron sign.

PART B - TRAFFIC CONTROL DEVICES

- ensure that the warning cones are correctly spaced and located along the line being painted. Cones displaced by traffic should be reset in position without delay,
- observe the progress of the work and move the flagmen and warning signs as soon as the paint has dried over a sufficiently long section of road,
- the work must be organised so that all painted areas will be traffic-dry by the time cones and signs have to be removed at the end of the day's work,
- remove any unwanted markings using a blowlamp and scraper. Do not overheat the bitumen road surface.

Road line-marking can also be carried out using mechanical equipment, for example hand or self-propelled line-marking machines. The manufacturer's instructions regarding the care and maintenance of the machine must be strictly followed in order to ensure that they function reliably. All other precautions and preliminary works will be the same as for manual methods. The temporary sign-posting must however be moved at more frequent intervals to keep pace with the faster progress of the work. More traffic cones will be required.



PART B - TRAFFIC CONTROL DEVICES



Replacing sign

- remove damaged sign, supporting post and, if necessary, the foundation block,
- locate replacement sign as close as possible to the old one in the correct location and orientation,
- excavate the new post foundation, trim the foundation sides vertical. The foundation for a single post standard sign would be at least 30 cm x 30 cm wide and 50 cm deep if a concrete backfill is used. The foundation should be at least 90 cm deep for soil backfill,
- assemble replacement sign on new post, tightening all bolts, nuts and screws,
- for concrete backfill prepare a mix (1 cement : 3 sand : 6 stone*) adding only enough water to obtain a workable mix,
- erect new post in the middle of the foundation. Use temporary struts to hold post in position and check for alignment and orientation,
- the sign must be slightly turned away from the road so that mirror reflection (caused by headlights at night) is avoided,
- pour concrete and compact with a hand rammer, or place and compact soil in 10 cm layers,
- smooth the concrete surface to a slight slope downwards from post to edge of foundation,
- remove damaged sign, surplus soil, and concrete and all debris from the site. Do not leave any part of the old sign exposed above ground level. Reinstate the area of the old sign.

*Graded crushed stone or gravel.

PART B - TRAFFIC CONTROL DEVICES

■ Repairing or Relocating Kilometre-stone

Kilometre stones are necessary to inform road users of their location, and to identify and locate maintenance works.

They are normally relocated in a simple excavation which is then backfilled with soil. The depth of the excavation depends on the size and shape of the kilometre-stone.

The location is normally determined and staked out by the road surveyor.

Some kilometre-stones may be required to be more stable and therefore set on a concrete foundation.

The kilometre-stone should be set as far back from the road edge as possible or as far as the shoulder* width will allow, and yet be visible to road users. It should not be placed on the edge of an embankment* or road ditch* where tilting or settling is likely.

* See *List of Terms, Volume 1*.

PART B - TRAFFIC CONTROL DEVICES

a) Kilometre-stone with concrete foundation

- when relocating the existing kilometre-stone, remove it from its concrete foundation. Backfill the excavation and compact until the surface is level with the surrounding ground,
- transport new or existing kilometre-stone to its new location fixed by the surveyor. 2 Stakes and a line should be used to set out the location and face of the kilometre-stone,
- excavate the new foundation to allow for 25 cm concrete around the perimeter and 10 cm under the base. The sides should be vertical and the base level,
- place a 10 cm layer of dry-mix concrete (1 cement : 3 sand : 6 stone*) in the foundation and compact,
- place kilometre-stone on the dry concrete bed, check its level and orientation. Mix just sufficient water to make the rest of the concrete workable and backfill the foundation with the concrete until it is slightly above the ground level. Trowel the concrete surface smooth and to a slight slope downwards to the edge of the concrete,
- if necessary repaint the kilometre-stone as described on Page IV - 117,
- remove excess soil, concrete and debris from the site.

**Graded crushed stone on gravel*

PART B - TRAFFIC CONTROL DEVICES

b) Kilometre-stone without concrete foundation

- excavate the foundation at the location fixed by the surveyor and deep enough for stability (usually half the depth of the kilometre-stone) and wide enough to allow for compaction of the backfill with available hand rammers,
- level off foundation base and compact with the hand rammer,
- centre the kilometre-stone in the foundation excavation, check plumb and correct orientation,
- backfill evenly around the kilometre-stone base in loose layers not exceeding 10 cm, compact with the hand rammer,
- as soon as the compacted backfill has reached a level slightly higher than the surrounding ground, smooth-off the soil surface and remove surplus soil away from the site.

PART B - TRAFFIC CONTROL DEVICES

4.4 COMPLETION AND REMOVAL OF TEMPORARY SIGNS

- clean tools.
- load all tools, equipment and surplus materials onto the truck. The carriageway* and shoulders* **must be left in a tidy and clean condition.**
- collect all cones, warning signs, flags and barriers in the reverse order to placing them, and load them onto the truck.
- proceed to the next site or back to the depot.
- clean the temporary traffic signs on return to the depot.

**See List of Terms, Volume 1.*

TYPICAL WORK REPORT
TRAFFIC CONTROL DEVICES

PART B - TRAFFIC CONTROL DEVICES

4.5 WORK REPORT

- The report must be filled in each day, detailing:
 - the work carried out,
 - the resources used.

PART B - TRAFFIC CONTROL DEVICES

4.6 STORING AND TRANSPORTATION

All districts of the highway maintenance organisation should have a supply of traffic control devices in storage for use:

- as temporary and maintenance works signposting,
- as replacement items and
- in new locations.

Certain permanent regulatory signs have a legal status and stocks of these should be held to immediately replace any damaged signs.

Signs, support posts, guide-posts, barriers, paint and other items in constant use and demand by the maintenance gangs will represent the bulk of the stock.

General guidelines for storage:

- always store signs, road markers and other items in a dry building where they cannot be damaged. Signs can be laid flat in shelves or stored vertically. Always use heavy paper or cardboard as spacers between each sign to prevent scratching. Identical items are to be stored together for ease of location,
- paints and solvents should be stored in a well-ventilated fire-proof room (brick or concrete walls, ceiling and floor). Store smaller cans on shelves and larger heavier drums on timber floor spacers to reduce the risk of attack by rust. Where paint is stored for a long time the cans can be turned occasionally to prevent settling. Use old stock first,

PART B - TRAFFIC CONTROL DEVICES

- paint brushes can be stored almost indefinitely provided they are clean and dry. After use they should be thoroughly cleaned and returned to the store,
- check warning lights for satisfactory operation at least once a month. If kerosene lamps are used, keep 2 or more ready for immediate use with filled tanks and adequate wicks.

Electric batteries deteriorate in the course of time even when not used. Dispose of old and weak batteries.

- load, transport and off load traffic control items with care. Rough handling or dropping can cause scratches which reduce service life. During transportation, protect all painted surfaces with sufficient cardboard or timber spacers.

Do not allow any item to bounce around on the bed of the truck. On arrival at the maintenance site unload all items carefully.

Do not throw items from the truck onto the ground.

PART B - TRAFFIC CONTROL DEVICES

5. REGULATORY SIGNS

These signs have a legal status and must be obeyed by road users. All regulatory signs used in the area of responsibility of the road authority should be kept in stock for immediate replacement of damaged signs.

Some examples of regulatory signs are shown opposite.

PART B - TRAFFIC CONTROL

6. STANDARD TEMPORARY SIGNS

The diagrams on the opposite and following pages show traffic control devices for maintenance sites on paved and unpaved roads. They are intended to include all essential temporary signposting that will be required for the maintenance works described in this Handbook. Local laws, regulations or practices may necessitate the provision of other temporary signs. Suggested signposting plans are shown in each of the 4 Volumes of the Handbook for the individual maintenance activities.

Notes and Sketches

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User of this Handbook:

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ACKNOWLEDGEMENTS

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

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

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

ACKNOWLEDGEMENTS continued

Any revision of this kind is an ongoing process, and comments or suggestions for further improvements should be made known to the PIARC Central Office at 27 rue Guenegaud, 75006, PARIS, France.

Fax: +33 (1) 46 33 84 60.

J. Stuart Yerrell
Chairman, Subcommittee C3-6d

WHAT IS PIARC?

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

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

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

within the context of wider policies towards transport.

To achieve these aims PIARC:

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

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

It was granted consultative status, category II, to the Economic and Social Council of the United Nations in 1970. The official languages of PIARC are French and English.

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

As of 1 January 1994, PIARC has 72 member Governments and 2,100 members in 100 countries.

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

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

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

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

▪ **COMMITTEES**

C1 - Technical Committee on Surface Characteristics
C3 - Committee on Technological Exchanges and Development
C4- Committee on Interurban Roads
C5 - Committee on Road Tunnels
C6- Committee on Road Management
C7- Technical Committee on Concrete Roads
C8- Technical Committee on Flexible Roads
C9- Economic and Finance Committee
CIO- Committee on Urban Areas
C11 - Committee on Road Badges
C12 - Technical Committee on Earthworks, Drainage, Subgrade
C13 - Committee on Road Safety
C14 - Committee on the Environment

▪ **WORKING**

G 1 - PIARC Winter Road Congress
G2- Natural Disaster Reduction
G3- Modern Traffic Control and Management
G4- Heavy Freight Vehicle Issues

- **PIARC PUBLICATIONS** - Committees and Working Groups publish synthetic documents, recommendations and state of the art. These documents, intended for decision makers, design and field engineers and researchers, are based on wide international consensus.

- **CONGRESS DOCUMENTS** - The documents published on the occasion of World Road Congresses are an invaluable source of information and experts agree on the fact that they are most interesting and unique.

- **PERIODICAL BULLETIN "Routes/Roads"** - *The Association Bulletin* was issued for the first time in 1911. It features comprehensive files on road matters in various countries, articles written by members of Committees and Working Groups and news of interest to the world road community. Its issues of a hundred pages are published three to four times a year.

- **TECHNICAL DICTIONARY OF ROAD TERMS AND LEXICON** -The first edition of the *DICTIONARY* was issued in 1931 The sixth edition (French/English) was published in 1990. The Dictionary is published with the financial support of UNESCO and is translated into eighteen languages: Arabic, Chinese, Croatian, Czech, Danish, Dutch, German, Greek, Hungarian, Italian, Japanese, Lithuanian, Polish, Portuguese, Romanian, Russian, Spanish and Slovak. The *Lexicon* contains over 12,000 expressions in English and French and is also available on computer disk.

All these documents are published in French and English PIARC publications catalogue is free of charge and can be ordered through:

ANRTP
32, rue du Marché commun
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44082 NANTES Cédex 03 (FRANCE)
Fax: +33 40 50 13 64

WHERE TO ORDER THE HANDBOOK

The English version of

- Volume I: Maintenance of Roadside Areas and
Drainage
- Volume II: Maintenance of Unpaved Roads
- Volume III: Maintenance of Paved Roads
- Volume IV: Maintenance of Structures and Traffic
Control Devices

may be ordered from:

Transport Research Laboratory
Crowthorne, Berkshire RG11 6AU
United Kingdom

The Road Maintenance Handbook is also being published in French, Spanish and Portuguese. Other languages are under consideration. For more details, please contact PIARC Central Office - 27 Rue Guenegaud, 75006, PARIS, France. Fax: +33 (1) 46 33 84 60.

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