Government of Nepal

Ministry of Local Development
Department of Local Infrastructure Development and Agricultural Roads
(DoLIDAR)

Rural Road Maintenance
Technical Handbook

Falgun 2065 (Feb/March 2009)

1. Introduction

1.1 Need for Rural Road Maintenance Technical Handbook

For the past few years the repair and maintenance of rural roads is being executed through local agencies. In order to execute the work of repair and maintenance of rural roads through local agencies in a planned, effeftive and uniform manner, the Ministry of Local Development (MoLD) has framed and enforced the Rural Road Maintenance Directives.

As stipulated in the Rural Road Maintenance Directives, the Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR) has framed and enforced this Rural Road Maintenance Technical Handbook for use by the site technicians concerned and road repair and maintenance length workers.

1.2 Objectives of Rural Road Maintenance Technical Handbook

This technical handbook has been prepared as a reference material for the technicians of the district technical offices under the District Development Committees (DDCs) involved in the repair and maintenance of rural roads. The objective of this handbook is to help the technicians identify the problems related to road repair and maintenance, devise right solutions to the problems, and introduce uniformity in the rural road repair and maintenance system.

An attempt has been made to develop this technical handbook as a simplified reference material for the planning and execution of inspection and repair and maintenance of roads.

Planned and systematic repair and maintenance saves means and resources by improving the safety condition of the road. The key to systematic repair and maintenance lies in regularly carrying out petty tasks instead of major and costly tasks after a delayed and prolonged time period. This aim can be met only if the technicians involved in the repair and maintenance work have detailed information on the sections of the road under their responsibility. This would help identify the trouble-prone areas of the road and regularly take care of them before a major and costlier problem crops up.

1.3 Users of Rural Road Repair and Maintenance Technical Handbook

This directives/guidelines [or handbook?] is to be used by the technicians involved in the repair and maintenance of the roads under the district technical offices, road repair and maintenance length workers and the supervisors overseeing their work.

1.4 Main Contents of Rural Road Maintenance Technical Handbook

This directives/guidelines [handbook?] has eight sections:

1. Introduction
2. Rural Roads and their Repair and Maintenance
3. Types of Rural Road Repair and Maintenance
4. Routine Repair and Maintenance
5. Recurrent/Occasional Repair and Maintenance
6. Periodic Repair and Maintenance
7. Preventive Repair and Maintenance
8. Emergency Repair and Maintenance

In addition, this directives/guidelines [handbook?] contains …. related appendices.

1.5 Limitations of Rural Road Repair and Maintenance Technical Handbook

This Rural Road Repair and Maintenance Technical Handbook should not be taken as the bible on repair and maintenance. As working methods are improved over time, these should be revised to suit the changed road condition. Hence, it is equally necessary to incorporate appropriate latest technologies that are in currency in the Repair and Maintenance Handbook. For this, this technical handbook will be evaluated and revised from time to time. The technicians involved in the repair and maintenance of rural roads must play an important role in this task. They are requested to continuously examine the suggestions given in the directives/guidelines and make available information on their efficacy, including suggestions for improvement, to the DDC and DoLIDAR through the district technical offices.

2. Rural Roads and their Repair and Maintenance

The term 'road repair and maintenance' denotes the activities that are to be carried out for the routine, effective and sustainable operation and use of roads and physical structures associated with roads.

2.1 Objectives of Road Repair and Maintenance

Road repair and maintenance is undertaken to keep the road in working condition by mitigating the dual effects of road surface deterioration and road material loss through long-term use of the road and environmental impact.

The repair and maintenance of roads is done with the following objectives:

- To keep the road service operational.
  Traffic should move on the road without disturbance.
- To reduce the transportation cost and travel time
  The time taken to travel from one place to another by road and its operational costs should be minimal.
- To minimize the chances of accident
  Arrangements should be made for the everlasting safety of all road users, including wayfarers.
- To reduce the need for costlier and more complicated repair work
  Roads should not be damaged to the extent that they require overall rehabilitation and reconstruction.
- To ensure long-term use of roads and preserve road assets
  As roads that are properly repaired and maintained have better longevity, it helps in securing optimal returns on investment, along with preservation of road assets.
- To prevent environmental loss
  Roads should be kept clean. In addition, roads and the environmental loss from roads should be kept minimal.
- To give continuity to social and economic achievements.
  The social and economic achievements of strengthened rural access should be given continuity through proper repair and maintenance of roads.

2.2 Causes of Deterioration of Rural Roads

Rural roads deteriorate because of the following causes:

- **Climatic and Environmental Effects:**
  Since very few vehicles drive on Nepal's rural roads, the condition of rural roads deteriorate because of climatic and environmental effects rather than the movement of vehicular traffic.
- **Poor Drainage Management**
  Due to various causes, water enters the road and flows over its surface. Uncontrolled flow of water washes away the soil on the surface and shoulders of the road, in the process damaging the road. Poor drainage management of roads is the main cause behind the caving in of roads.

- **Lack of Routine Repair and Maintenance**
  If the routine repair and maintenance is neglected, cyclic gowth of damage and collapse of roads takes place.
- **Improper Use of Vehicles**
  Generally, when transportation vehicles, tractors and bullock carts carrying loads more than their carrying capacity and vehicles of type other than those specified drive over them, roads damage earlier than their lifespan. The movement of such vehicles damage rough roads to an even greater extent during rain.

Only up to 6 tonnes

- **Lack of necessary quality standards in design, construction and repair and maintenance work**
  If the design, construction and repair and maintenance work of roads and structures associated with roads does not comply with the technical standards and quality specifications, the possibility of damage and collapse of roads is greater.

Things to Know

1. Preventing damage to the road in fact is as good as mobilizing necessary resources for its repair and maintenance.
2. Experiences indicate that labour-intensive technology is extremely effective for gravelled and earthen/rough roads. Labour-intensive technology, if properly used, could be less costly than mechanized technology. If trained and skilled, supervisors can make excellent use of the labour force. As labour-intensive technology provides poor local workers with work, it significantly contributes to poverty alleviation efforts.
3. Labour should be provided with proper and quality tools to raise their productvity.
4. Tractors and heavy vehicles are among the causes behind collapse and damage of rural roads.
5. In the routine repair and maintenance of earthen or gravelled roads, priority should always be given to the repair and maintenance of the drainage system.
6. Uncontrolled/unmanaged rainwater is the main cause of damage of drainage systems. Sediments should not be allowed to accumulate in the drainage system.
7. Grasses and saplings should be sufficiently planted to prevent damage to the slopes on both edges of the road.
8. Prompt preventive measures against problems arising from the drainage problem, however minor they are, can prevent possible big damage.

2.3 Rural Road Repair and Maintenance Plan

Work should be executed in a planned manner to enhance the effectiveness of road repair and maintenance work and utilize the available means and resources. Routine and recurrent/occasion repair and maintenance call for planning petty jobs at short intervals round the year. Jobs that require a notable degree of regravelling are scheduled at more than one year's interval.

Since a variety of information is necessary for formulating a plan, the technicians involved in road repair and maintenance should draw up an inventory of items required for repair and maintenance of the roads under their jurisdiction.

While formulating a rural road repair and maintenance plan, answers to the following questions should be explored:

- **What** type of repair and maintenance is required for the road?
- **When** should the repair and maintenance work be carried out to maintain the service quality of the road?
- **Where** should the repair and maintenance be carried out and in what order?
- **How** should the proposed repair and maintenance work be carried out?
- **Who** should carry out the proposed repair and maintenance work?

This Rural Road Repair and Maintenance Technical Handbook provides general information on all five questions mentioned above, especially focusing on how to execute the task.

2.4 Report on Road Repair and Maintenance

The technicians involved in the rural road repair and maintenance have to regularly prepare reports in the course of execution of site inspection and repair and maintenance programme. This helps the road repair and maintenance work in the following ways:

- Information is obtained on the progress, efficacy and quality of the repair and maintenance work being executed.
- The number of vehicles driving on the road and the quality of service to be made available accordingly can be determined.
- The trouble-prone areas that call for special attention, including landslide-prone areas where vehicular movement could potentially be disturbed and accident-prone areas, can be identified.

The technicians involved in road repair and maintenance work should submit reports to the office concerned every week, by including details of labour, construction materials, equipment and daily work progress, for every repair and maintenance work.

3. Types of Rural Road Repair and Maintenance

The prevalent climate, vehicle types, vehicular load and pressure, engineering design, quality of road construction and type of road surface (earthern, gravelled, blacktopped), etc determine the appropriate time, type of repair and maintenance, and required budget.

The following five types of repair and maintenance work are done on rural roads.

3.1 Routine Repair and Maintenance

Routine repair and maintenance covers petty repair and maintenance jobs on all roads to be carried out round-the-year. General types of repair and maintenance jobs to be carried out on routine basis are especially done without prior estimation and assessment, and are of specific nature. Those routine jobs that are carried out for keeping the road in an appropriate shape and preventing their quality from deteriorating fall under it. Usually, such jobs do not require skilled workforce. Such jobs, which incur fixed costs, are normally executed by length persons through user committees.

3.2 Recurrent Repair and Maintenance

Minor repair and maintenance jobs that are to be done at different times of the year but that are not covered by routine repair and maintenance fall under recurrent/occasional repair and maintenance. Those repair and maintenance jobs that are done recurrently (two or three times) in a year in order to protect the road from damage that have occurred, or could occur, due to the types and pressure of vehicles and rains are called recurrent/occasional repair and maintenance. Such jobs even require skilled labour force. Such jobs should be identified and their cost estimates done before executing repair and maintenance.

3.3 Periodic Repair and Maintenance

This covers major repair and maintenance jobs that are to be done at an interval of a few years. Since routine and recurrent repair and maintenance cannot always maintain the road condition, those types of repair and maintenance jobs that call for relatively a lot of work fall under this. Such repair and maintenance work is done once every five to seven years on blacktopped roads, three to five years on gravelled roads and two to three years on earthern/rough-weather roads, considering the condition of the road. However, in some rural roads periodic repair and maintenance may become necessary every year, especially after the monsoon. Such jobs usually require skilled workforce. Jobs should be identified and their cost estimates done before executing repair and maintenance.

3.4 Emergency Repair and Maintenance

Emergeny repair and maintenance is done in situations when movement is stalled due to unexpected natural or accidental obstructions on the road. The repair and maintenance that is carried out to immediately open the road to traffic and operate the disturbed traffic and protect the road from additional damage and loss when traffic movement comes to a standstill due to an obstruction or closure of the road due to any natural or unforeseen cause or there is a danger of damage and loss to the road is called emergeny repair and maintenance.

The job of restoring the damaged road to its original condition after the completion of the emergency repair and maintenance work doesn't come under this title.

3.5 Preventive Repair and Maintenance

The repair and maintenance jobs that are carried out to protect the road from possible damage in the future and to extend the time interval for doing restoration work are known as preventive repair and maintenance. These jobs are determined by geological, geographical and environmental causes. As it is not possible to fix an appropriate time for execuring this type of repair and maintenance, efforts should be made for carrying out such tasks as soon as it is deemed necessary as far as resources available permit.

4. Routine Repair and Maintenance

The following tasks come under routine repair and maintenance:

4.1 Cleaning of watercourses/channels
4.2 Clearing of small and medium landslides on the road surface
4.3 Maintaining of the road surface
4.4 Grubbing of unwanted grasses and weeds growing on the edges and walls of the road
4.5 Routine repair and maintenance and cleaning of the support wall
4.3 Maintaining of the road furniture
4.7 Resolving of miscellaneous potential problems
4.8 Preparing of reports on the repair and maintenance jobs that do not fall under routine repair and maintenance

4.1 Cleaning of watercourses/channels

Why

Accumulation of various types of sediments, including soil and weeds, in the inlet/mouth and outlet of watercourses/channels constricts the waterway. Because of this, the water flows over the road surface. Therefore, drains and culverts should be kept clean to maintain the efficacy of the road.

How

- Regularly clean the soil, weeds and other waste materials and unwanted stones/pebbles that have accumulated in the watercourses/channels and dump them in a proper and specified secure place.
- In case the drain has a steep slope, regularly inspect and clean the scour checks constructed on the drain to prevent erosion of the surface of the drain.

Things to Mind

- Drains and watercourses/channels should always be kept clean and open.
- The soil and waste materials dug out during the cleaning of the drain should not be dumped on the edges of the drain or the shoulders of the road.
- If kept on the edges or shoulders of the road, during rainy season, water can transport the soil and waste materials on the edges back into the drain, and the soil on the shoulders can spread over the road surface and obstruct vehicular movement.

An overfilled drain that needs to be immediately cleaned

4.2 Clearing of small and medium landslides on the road surface

Why

As the heaps of stones and earth and small and medium landslides that have fallen on the road obstruct vehicular movement, damage structures and block drains, water flows onto the road surface, which damages the road. Hence, it is necessary to regularly clear such landslides.

How

- Landslides of up to 1 cubic metre that can be cleared by one single labour in three or four hours are deemed small and medium landslides.
- Piles of stones and earth carried by landslides should be used, as far as possible, for filling up potholes/depressions, or else dumped in a secure place.
- Major landslides should be cleared by engaging a large number of labour under emergency repair and maintenance.

Things to Remember
The small landslides remaining after clearing a landslide act as a preventive measure against other landslides.

A landslide on the road surface that needs to be immediately cleared.

4.3 Maintaining the Road Surface

Why

A road surface that has softened due to water can easily collapse under the pressure of traffic movement. In a normal state, too, motor wheels make furrows by pressing weak earth/gravels. In this process, the water accumulating in the depressions weakens the compact earth around it, and damages the road surface, as vehicular pressure builds up. To prevent this, the depressions and damaged portions must be repaired and maintained in time.

Things to Mind

If minor repair and maintenance is not done in time, it can subsequently give rise to major damage; so, it is essential to pay attention to such jobs without delay.

How

- Plant grass tufts on damaged shoulders to prevent further damage.
- If road shoulders rise above the road surface, build a guardrail by grating the road surface to allow the water to flow from the road to the shoulders.

Let's not drive in the rain!

The furrows made by motor tyres should immediately be filled up.

4.4 Grubbing of unwanted grasses and weeds growing in the edges, shoulders and walls of roads

Why

The growth of unwanted weeds and shrubs in the edges, shoulders and walls along the road can adversely affect the sight distance necessary for drivers and movement of vehicles. Weeds growing in an uncontrolled manner increase the chances of accidents by obstructing the sight distance necessary for drivers driving on two-way roads, especially at bends. Apart from this, this task is done to mitigate the negative effects on watercourses and both shoulders of the road.

How

- Pluck out the unwanted grasses and weeds growing on the shoulders and walls before the onset of monsoon or immediately after the monsoon and dispose them of at a proper place.
- Remove the weeds growing in the watercourses and both shoulders of the road.
- Remove the bushes and shrubs that obstruct the sight distance.

Trees that obstruct the oncoming vehicles.

A drain that needs to be immediately repaired and maintained by placing scour check

4.5 Routine Repair and Maintenance and Cleaning of Support Wall

Why

Stone masonry, gabion boxes filled with stones and concrete are used for constructing support walls. Weep holes are made in the support walls of masonry and concrete for draining water. Water outlet can get obstructed if vegetation grows or sediment accumulates in weep holes. Apart from this, the roots of growing vegetation can damage the support wall. Routine repair and maintenance should be carried out to protect the support wall.

How

- Remove the vegetation in the weep holes and joints of the support wall.
- If there are scours on the base of the support wall, such places should immediately be filled with stones and a report submitted for permanent solution.

Wall of dry stones requiring immediate repair and maintenance

4.6 Maintaining of Road Furniture Erected on the Road

Why

Traffic signs, reflectors, delineators, guide/sign posts, milestones, road markings, etc are erected on the road to streamline the road operation,. Such road furniture should properly be maintained by regularly repairing and maintaining them.

It is our right to be informed!

How

- Maintain indicators signs and make them legible by cleaning them after removing bushes, shrubs and weeds.
- Remove the dust and soil that have settled on traffic signs.
- Repaint severed colours and old and illegible markings.
- Set straight tilting signboards and posts.
- Do packing around the loose support.
- Replace new nuts and bolts wherever they are missing.
- Fasten loose guardrails.
- Periodically submit report on the faults that have been, or have not been, repaired and maintained on periodic basis.

A noticeboard after being cleaned.

Things to Mind

Sometimes roadside neighbours have been found to disfigure or damage road furniture such as milestones and indicator signs. The measures for solving such problems are described in Section 5.1.5, Coordination with Roadside Neighbours.

4.7 Solving of miscellaneous potential problems

Why

It is found that red clay is excavated near roads for daubing/whitewashing the house. If clay is excavated without any regulations, roads could get damaged from landslides or cave in. Therefore, the people living around roads should be duly informed, from time to time, about the potential risks of, and damage from, excavating clay and prevented from excavating clay in an unsystematic manner.

As seepage of water from irrigation channels operating in the *pakha* (non-irigated fields in hills) on both sides of the road could cause landslides and damage roads, it is necessary to prevent such events.

How

- Plug seepage of water from the walls of the road and *pakha* in consultation with stakeholders.

- Encourage farmers to grow, as far as possible, cash crops that need less irrigation instead of crops that need continuous irrigation.
- Jointly work with roadside neighbours to protect the road by discouraging the practice of excavating stones and earth from road shoulders for constructing houses and cattle sheds.

Let's Think!
Let's not damage the road by excavating red clay for whitewashing our houses and courtyards.

Damage caused by excavating red clay from road edges.

4.8 Report on Repair and Maintenance other than Routine Repair and Maintenance

The supervisor/overseer/engineer should prepare reports on the repair and maintenance that cannot be carried out under routine repair and maintenance other than those mentioned above and submit them to the repair and maintenance committee/DDC/VDC for recurrent, periodic or emergency repair and maintenance.

4.9 Routine repair and maintenance that are to be carried out as per season and their order of priority

Season	Repair and Maintenance Tasks	Priority
Dry season	• Repair and maintenance of the road furniture • Repair and maintenance to maintain the road surface	1 2
Before monsoon	• Cleaning the watercourses • Repair and maintenance of other structures on the road • Solving miscellaneous potential problems	1 2 3
During monsoon	• Clearing the small and medium landslides that have fallen on the road surface • Cleaning and repairing and maintaining watercourses	1 2
After monsoon	• Repair and maintenance for maintaining the road surface • Cleaning the watercourses • Removing unwanted grasses and shrubs growing in the edges and walls of the road	1 2 3

5 Recurrent/Occasional Maintenance

The following tasks fall under recurrent/occasional repair and maintenance:

5.1 Recurrent/occasional repair and maintenance of watercourses.
5.2 Repair and maintenance of the road surface
5.3 Repair and maintenance of both shoulders of the road
5.4 Repair and maintenance of road furniture

5.1 Recurrent/Occasional repair and maintenance of water courses

5.1.1 Recurrent/Occasional repair and maintenance of side and diagonal drains of the road
5.1.2 Recurrent/Occasional repair and maintenance of cross drainage
5.1.3 Recurrent/Occasional repair and maintenance of the causeway

5.1.1 Recurrent/Occasional repair and maintenance of side and diagonal drains of the road

Why

If waterways such as side and diagonal drains of the road are damaged, and it is not detected and repaired and maintained in time, it could seriously damage the road. Therefore, the efficacy of the road must be maintained by carrying out recurrent/occasional repair and maintenance.

Things to Mind

1. While inspecting the road for recurrent/occasional repair and maintenance, the condition of the drain and the damage to its different parts should be determined.
2. In the case of clay/earthen drain, whether the cross-section is correct or not and whether there is a problem of drain erosion or not must be looked into.
3. Whether the roadside neighbours are blocking or filling up the drain and using it as an irrigation channel should be ascertained.
4. If the drains are severely damaged to the extent that they do not fall under recurrent/occasional repair and maintenance work, a report should be prepared and submitted to the officer concerned for execution under periodic repair and maintenance.
5. The people living near the road should be made aware of the importance of drainage and the damage that could arise from the clogging of drains.
6. If any residents are found encroaching on the drain by indiscriminately throwing waste into it or damaging or demolishing or obstructing it, they should be persuaded to desist from doing so in the future.
7. This might even necessitate DDC's and local administration's cooperation.
8. If the repair and maintenance of the road or drain is done in coordination with, or even with the involvement of, the local residents living near the road, the repair and maintenance will be even more sustainable.

Draining water by cutting the diagonal drain

How

- If the cross-section/structure of the drain has been damaged by caving in, restore it to its original conditions by clearing the obstruction.
- If the drain has been damaged through erosion caused by steep slope, build stone or bamboo scour checks, as necessary.
- In case there is a problem of the delineator being changed due to frequent erosion/breaching, drain water by constructing diagonal drains at short distances (approximately 30-40 metres) during the rainy season and pave stone slabs, as far as the budget allows.

A drain that calls for repair and maintenance in coordination with local residents.

5.1.2 Recurrent repair and maintenance of cross drainage

Why

Cross drainage means stone culverts, pipe culverts, slab culverts or culverts below the road. If cross drainage is not repaired and maintained in a routine manner, the road can get damaged and traffic movement obstructed.

How

- Refill stones in the places where the stones of cross drainage have come loose or have fallen off.
- Clean the catch pit and bottom/base of the drain.
- Protect the support/shelter wall and other protective works constructed in the front and back of the drain.l
- Inspect the stone slabs used for covering the drain and, if necessary, repair and maintain them by placing additional stones or replacing them with new ones.
- In the roads constructed according to the green road concept, repair and maintain the stone scuppers constructed for draining water

A cross drainage that calls for immediate repair and maintenance

5.1.3 Recurrent/Occasional Repair and Maintenance of Surface Culvert/Causeway

Why

In most surface culverts, sediments such as soil and heaps of fallen leaves accumulate so that water doesn't spread over and flows by meandering from one place to another. Such flowing water erodes and damages the surface of the culvert. To prevent occurrence of such problems, the sediments accumulating on the bottom of the culvert should be cleaned and thrown into a designated area, and the mouth and the outlet of the surface culvert levelled to spread the meandering water.

How

- Take necessary action so that water flows over the entire length of the surface culvert.
- Carry out necessary repair and maintenance to maintain the road surface.
- If gaps have been created through collapse of cobbled stones, repair and maintain them.
- In case there are breaches in the inlet and the outlet of the surface culvert, repair them.
- In case of seepage (piping action) of water from top to bottom, take preventive measures.

5.1.4 Recurrent repair and maintenance of the headwall and catchpit

Why

If the headwall, abutment, wing, catchpit and bottom of the culvert are damaged, repair and maintain them to restore them to their original condition.

How

- Fill up the small and medium cracks between joints with cement mixture and cement mortar.
- If there are big cracks, identify the causes and promptly join them and monitor.
- Remove the temporary packings done in the course of routine repair and maintenance and do joining work.
- Remove the loose stones in the machinery and carry out the joining work.
- Clean the weak joints and fill them with fresh mortar.
- Identify the causes for damaged concrete and sunk bed and carry out necessary repair and maintenance.
- If water is flowing after accumulating at one place and striking the wings, mend it.
- Make sure that the culvert is not damaged because of the drain outlet or any other causes.

5.1.5 Coordination with Roadside Neighbours

Why

If the repair and maintenance of the drain/surface culvert is done in coordination with roadside neighbours, it will be long-term.

How

- Enlighten the neighbours of the importance of the drain.
- If they are found encroaching upon the drain by building a footpath by filling up the drain, repeatedly throwing garbage in the drain or other ways, enlighten them.
- If there is no change in the roadside neighbour’s behaviour even after this, submit report to the superior officer by enclosing details of such section.

5.2 Recurrent Repair and Maintenance of Road Surface

Why

As the road surface gets damaged by vehicular movement, weather, quality of construction materials and lack of proper water management, etc, recurrent repair and maintenance should periodically be done to lengthen the longevity of the road and maintain its service quality.

Things to Mind

1. Before inspecting the damage seen on the road surface in the course of recurrent/occasional repair and maintenance, the report of the periodic repair and maintenance should comprehensively be studied and a list of the places mentioned in that report and damage drawn up.
2. In addition, the report of the damage based on a cursory inspection of other places should be evaluated.
3. This helps in determining the need for recurrent/occasional repair and maintenance.

5.2.1 Recurrent repair and maintenance of blacktopped road

5.2.1.1 Pothole repair and maintenance

Why

The potholes seen on blacktopped roads should be repaired under the recurrent repair and maintenance to prevent possible accidents on the road and protect road assets.

How

- Erect indicator signs and safety angles around potholes.
- Draw a rectangular shape around the portion to be repaired and maintained with a chalk or paint.
- Excavate all road materials within the rectangular shape.
- Dig the pothole until its base is found and then dress the wall after setting it straight.
- Make the bottom of the pothole compact after leveling it.
- Apply tack coat on the bottom and sides.
- Fill the potholes with bitumen premix at one or more level of equal thickness and make it compact with a vibrating roller, if available, or a rammer/hammerhead, if not available.
- Examine the surface with a straight edge or thread and level it.
- Dispose of the earth and other waste dug out from the repair and maintenance site at a safe place outside the road.
- Remove the safety signs and open the road to traffic.

5.2.1.2 Repair and maintenance of cracks

Why

Cracks occur on the road surface due to the quantity of bitumen being less than necessary, inadequate compaction, operating of excessively heavy vehicles on the road, bitumen getting brittle over time, poor drainage of water from the surface, bitumen becoming old, thickness of the pavement being less than necessary and weak base. In order to protect the road from potential damage to the road surface and the base and sub-base under the surface through seepage of water and other waste, the cracks should be repaired and maintained under recurrent/occasional repair and maintenance.

Things to Mind

- In case the pavement structure is in good condition, wide cracks can be plugged with bitumen of low viscosity or slurry seal.
- Cracks that are very close to each other should be plugged with slurry of sand and bitumen. Slurry should be spread over without normally exceeding 5 millimetres in thickness.

How

- Erect indicator signs and safety angles at the work site.
- Keep the road surface clean and dry.
- Mark the area to be repaired and maintained with a chalk.
- Apply bitumen in the area marked with a chalk like for tack coat and use additional bitumen if extra bitumen enters the cracks.
- Apply coarse sand over the bitumen thus applied and sweep it with a broom.
- Remove the indicator signs and safety angles and open the road to traffic.

5.2.1.3 Repair and maintenanceof Pavement Edges

Why

The road becomes narrower through entry of water, lack of support due to decrease in the shoulder height, damage of the edges of the blacktopped pavement. If it is not repaired and maintained, the damage can spread rapidly, especially in the rainy season.

How

Repair and maintain damaged edges of the pavement in accordance with the procedure for pothole repair and maintenance described in Article 5.2.1.1.

5.2.1.4 Repair and maintenance of Rutting and Corrugation

Why

If heavy traffic is concentrated in a single track, or compaction of pavement is inadequate, or pavement mixture of low stability is used or bullockcarts operate massively, ruttings are seen on the road surface. Similarly, if less stable mixture is used, if the vehicle's springs create oscillations and if the surface course is not spread correctly, corrugations will appear. If ruttings and corrugations are not repaired and maintained as soon as they occur, travelling becomes uncomfortable, and water will seep through the layer, damaging the blacktopped layer prematurely.

How

- Repair and maintain ruttings of less than 50 mm depth by filling them up with bitumen premix.
- Repair and maintain ruttings more than 50 mm deep by removing the pavement structure of the affected area and spreading a fresh blacktop layer.
- Repair and maintain shallow corrugations by scraping the layer from the upper part manually or with the blade of a grader and filling it in the lower part or adding the premix that is in shortfall.
- Repair and maintain deep corrugations by removing the blacktopped layer from the affected area by scraping them and applying a fresh coat of premix.

5.2.1.5 Bleeding, Ravelling, Stripping

Why

If the proportion of bitumen in the mixture in the blacktopped surface exceeds the requirement, or the gradation is not correct, in the summer, bitumen gushes out and flows on the surface. This damages bitumen and also weakens the blacktopped surface. When bitumen flows on it, the road surface becomes slippery, creating chances of accident; therefore, the problems of bleeding, ravelling, stripping, etc should be resolved under recurrent/occasional repair and maintenance.

How

- Disperse coarse sand or tiny chips over the blacktopped surface to prevent it from becoming slippery.
- Because if the proportion of sand is low, the surface remains slippery, and if it is high, the surface becomes coarse and dirty, mix sand only in the right proportion.
- Scatter sand or rocks/pebbles in the sun and, if there is no sun, heated it up to 60 degrees centigrade.
- Sweep the sand or rocks/pebbles thus scattered with a broom from time to time so that they are uniformly spread over the affected area.
- Run a roller over the area where pebbles are scattered.
- In the sections where sand has thus been scattered, after opening the road surface to traffic for one or two days, clean the surface by sweeping away the sand that has not glued to bitumen.
- If the bitumen or main part of the surface gets damaged from excessive bleeding, submit a report about it.
- As faults such as aggregate stripping/ravelling arise due to low quantity of bitumen, seal such parts with slurry.

5.2.2. Recurrent Repair and Maintenance of Gravelled Surface

Why

As potholes, rutting and corrugation are made by erosion of the gravel on the road surface due to factors such as vehicles, weather, quality of construction materials and poor water management, and gravel erosion makes pits, the service quality of roads decreases and there is possibility of accidents. To repair and maintain the notable problems seen on the road surface of gravelled road, measures such as regarding, dragging, patching, regravelling should be adopted.

5.2.2.1 Regrading

How

- In the first and second passes, lay out the gravel in the damaged area by raking so that cambers are properly set.
- Sprinkle water on the surface that has been raked and the gravel that is to be added, in the required quantity.
- Add gravel in some percentage, as required.
- Check whether or not the camber of the surface is between 4 and 6 per cent, and, if it is not, set it.

- Do compaction from the shoulders to the centre with a roller. If the optimum moisture content is available, compaction is generally accomplished in the eighth pass.
- Grade the remaining portion of the road by repeating the method mentioned above.
- Do not run roller on the crown of the surface.
- If a grader is not available, fix the surface manually by scraping.

5.2.2.2 Dragging

How

- Spray water on every layer and make it compact with a rammer/hammerhead or roller.
- Check whether the surface is correct or not, and if it is not, correct it.
- While doing, move in the direction of traffic.
- While carrying out the dragging work, instruct a skilled worker to walk ahead and guide the traffic, instruct the drag to turn, and remove stones and other obstructions on the road.
- Considering the condition of the road surface and type of drag, do the dragging work at the speed of 5 to 10 kilometres per hour.
- Keep the length of the pass as much as possible.
- If tree branches or twigs or pieces of steel fall during dragging, throw them out of the road.

Things to Mind

- On the gravelled road surface, simple damage can be repaired and loose/stray materials can be removed from the road surface throughs dragging.
- In roads where the traffic pressure is low, the need for regrading can be minimized by doing dragging from time to time.
- Since dragging cannot repair camber and adjust corrugation, regrading is necessary.
- Tied bunches of small tree branches or old tyres tied with chain, or cable drag, steel drag, box drag, towed grader can be used as drag.

5.2.3.3 Repair and Maintenance of Potholes of Gravelled Surface

How

- Erect indicator signs and safety angles around potholes.
- Mark the portion that is to be repaired and maintained in a rectangular shape with a chalk or colour.
- Excavate all road materials within the rectangular mark.
- Dig the depth of the pit until its solid base is found and then dress the wall vertically.
- Fill the layer to 15 centimetres through appropriate gravelling.

5.2.2.4 Patch Repair and Maintenance of the Gravelled Surface

How

- Clean the area where the patch is to be repaired and maintained, and remove water and loose gravel.
- Cut the wall of the pit/ditch vertically.
- Estimate whether the moisture content of the gravel is correct or not, and dry it or spray water on it, as necessary.
- Lay gravel by layers of 10 cm or less each.

- Do the compaction of every layer with a rammer/hammerhead or roller.
- Check the road surface and camber and, if they are not correct, fix it.
- Clean the site and dump the unwanted materials in the store.

5.2.3 Recurrent/Occasional Repair and Maintenance of Earthen Road

Why

The iron wheels of bullockcarts soon make ruts in the rough road. Similarly, as other vehicles also usually use tracks, ruts are made in those tracks. If potholes and ruts are not repaired and maintained in time, vehicles will not be able to operate on earthen/rough roads.

How

- Fill up the pits and depressions seen on rough/earthen roads as soon as possible.
- Do the grading of the surface of the rough road in a sequential manner.
- As soon as grading is completed, do rolling by spraying required quantity of water, keeping in mind the moisture on the surface and in the gravels to be added.
- It is essential to repair and maintain the small pits seen on the earthen/rough road through the dragging process. Dragging should be done by following the methods described in Section 5.2.2.2 ‘Repair and Maintenance of Gravelled Road’.
- Grading is done to fix the camber, correct ruts and depressions, and adjust the cross-section on the road surface.

Things to Mind

- Earthen/rough roads excessively create dust pollution.
- The dust particles blown up by the wheels of moving vehicles rise up from the surface and make clouds of dust.
- This problem should be minimized by sprinkling water on the road, whenever possible, in the dry season.
- Grading of rough/earthen roads should be done as soon as the rainy season is over. After grading, rolling should be done by spraying water in appropriate quantity on the surface.

A road surface that needs recurrent repair and maintenance

5.3 Recurrent/Occasional Repair and Maintenance of Road Shoulders

Why

Since road shoulders are also used, in times of urgency, for giving way to other vehicles while driving, overtaking and parking vehicles, they should also be considered as part of the road surface for driving vehicles. As shoulders are also a part of the road surface, any damage to it should instantaneously be addressed. Shoulders give support to the road from both sides. If the damage to shoulders continues, the road will become narrower and obstruct vehicular movement.

How

- Correctly adjust/fix the cross slope of the shoulders.
- If shoulders have caved in, fill them up.
- If shoulders have breached so that they make ruts and corrugations, fix them.
- If weeds, tree branches and twigs, etc are obstructing shoulders, remove them.
- Keep the height of shoulders lower than that of the road.

5.3.1 Repair and Maintenance of Blacktopped Shoulders

Why

The main faults seen on blacktopped shoulders include potholes, ruts and damaged priming. The potholes seen in shoulders should be repaired and maintained as soon as possible to prevent shoulders from further damage.

How

- Potholes should be repaired and maintained by following the method described in Section 5.2.1.1 ‘Pothole Repair and Maintenance’.
- In the areas of the primed shoulders where priming has been damaged, priming should be re-done with bitumen.
- If stones in stone-paved shoulders have come loose or come out, the surface should be fixed by packing.
- It is equally necessary to check and adjust the cross-slope.

5.3.2 Repair and Maintenance of Non-blacktopped Shoulders

Why

Rutting, depression, erosion, damaged camber, dust, etc are the main problems seen on the shoulders that have not been blacktopped. If such types of damage on shoulders are not repaired and maintained in time, accidents might happen and pavement might get damaged.

How

- If damage is caused by breach of shoulders, explore its causes and do compaction by filling additional gravel.
- If 2 to 5 centimetres of gravel are to be added, scrape the old surface and add new gravel.
- Fix the problems of rutting, depression and breach through dragging or manually.

- Carry out grading by adding materials in necessary quantity, spraying water, fixing camber and, if possible, by doing compaction with a vibratory roller.
- The method of dragging and grading is described in Section 5.2.2.2.
- Address the problem of dust rising from shoulders by following the method described in Section 5.2.3 'Recurrent Repair and Maintenance of Rough/Earthen Road'.

Damaged shoulders that call for recurrent repair and maintenance

5.4 Recurrent/Occasional Repair and Maintenance of Road Furniture

Road furniture play an important role in strengthening the state of road security. Therefore, after checking whether the road furniture used on the road are in a good and effective condition or not, the tasks that could not be repaired and maintained under routine repair and maintenance should be executed under recurrent/occasional repair and maintenance.

5.4.1 Recurrent/Occasional Repair and Maintenance of Guard Rail, Parapet, Crash Barrier, Confidence Block

Why

Lack of timely repair and maintenance of damaged guard rail, parapet, crash barrier, etc increases the chances of accident. The road furniture that is not at a proper place and in a proper shape cannot be as effective as expected.

How

- If the wires in the parapet made of gabion, crash barrier and confidence block are not in good condition, repair and maintain them.
- If stones have been taken out or are not filled to capacity, fill up stones.
- If an additional barrier is required in the sharp bend of a hilly road or in bridges or culverts, build them for protection.

5.4.2 Recurrent/Occasional Repair and Maintenance of Milestones, Road Paint and Traffic Signs

Why

Milestones, road paints and diverse signs get damaged mainly because of weather, wear and tear, traffic and occasionally through roadside neighbours' behaviour. These should be maintained through repair and maintenance to duly inform drivers and travellers about the condition of road and destination and prevent accidents.

How

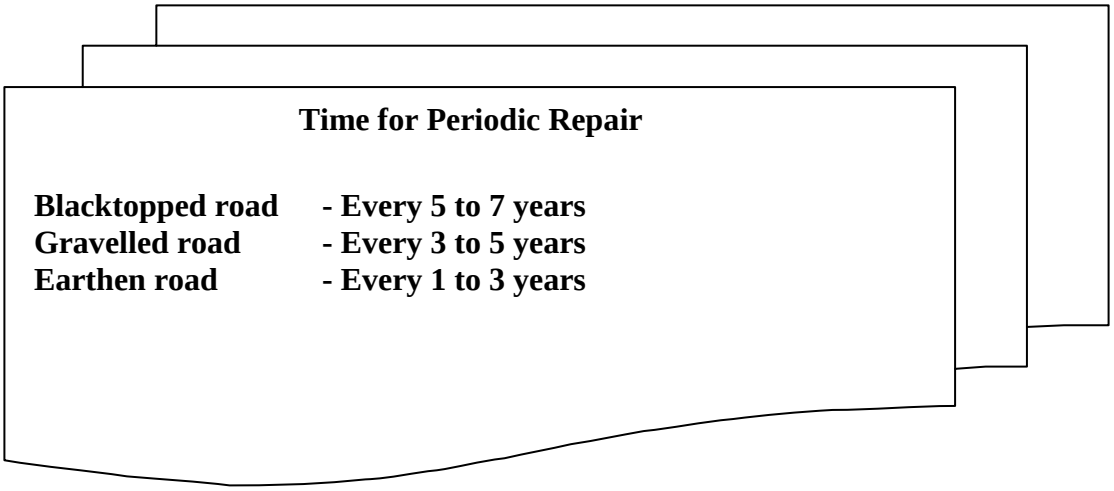
- If the steel posts, sign plates, guide posts and indicator signs have discoloured and have been erased, repaint them.
- Correct the erased or illegible signs, numbers and letters by rewriting.
- Replace broken or missing reflectors by new ones.
- Inspect all paintings, including central lines, used on the road surface, and repaint the faulty ones.
- Replace the damaged posts, replace the missing nuts and bolts, and fasten the loose bolts.
- Replace the damaged milestones, set straight the tilted ones and adjust their position.
- Repair and maintain and, if necessary, replace the embankments at relative height and the delineators used in bends and other places.
- If the indicator signs and milestones are concealed by bushes and shrubs and cannot be seen, trim the bushes and shrubs, and clean the indicator signs and milestones.
- Inspect whether or not the notice on the indicator signs and milestones are correct or not, and correct them if they are not.

Things to mind regarding recurrent/occasional repair and maintenance

- The programme should be submitted in the prescribed format by including the above tasks under the recurrent/occasional repair and maintenance in the beginning of every fiscal year.
- The detailed description of every task falling under recurrent/occasional repair and maintenance should be filled out in the prescribed format.
- Such reports that have been prepared by clearly indicating, among others, the area where the repair and maintenance has been carried out, the good that has been repaired and maintained, and the details thereof should be submitted to the office concerned.
- Such reports are of special help in preparing plans related to road repair and maintenance as well as managing the budget.

6. Periodic Maintenance

Periodic repair and maintenance is done not for structural strengthening of the road but for improvement of the road surface.



To formulate periodic repair and maintenance plan, it is essential to carry out in-depth inspection of the affected area, and listing and evaluation of damage. The reports on routine and recurrent/occasional repair and maintenance can significantly aid this task.

Things to mind while inspecting rural roads for periodic repair and maintenance

- Where, how many and what types of crack are seen on the blacktopped road surface.
- Whether or not re-marking is necessary on the road surface.
- Whether or not it is necessary to paint steel structures.
- Whether or not regravelling is necessary on the gravelled road surface.
- Whether or not regravelling or resealing is necessary on shoulders.

The following tasks are mainly done under periodic repair and maintenance.

6.1 Surface Dressing

Why

If a big portion of the blacktopped road surface gets damaged, if there are chances of the base getting damaged due to water flowing onto the surface through cracks or if the skid resistance of the surface diminishes, surface is repaired and maintained by doing surface dressing under periodic repair and maintenance.

How

- Prepare a workplan.
- Thoroughly check the necessary machinery, tools and materials.
- Ascertain whether or not the tasks of surface preparation such as repair and maintenance and cleaning of potholes and road edges have been completed or not.
- Work only when the weather is good.
- Make arrangements for the security of road users, length workers, vehicles, and machinery and tools by erecting makeshift indicator signs and security barriers.
- Clean the road surface with a broom or compressed air.
- Mark the road surface and align the edges with the help of a string line.
- Check the temperature of the binder and bring it to the correct level.
- Check the spread rate of the binder and calibrate it.
- Make regular transverse joints at the end part of the pass of every binder spray by placing pieces of thick paper such as cardboard, tarfelt, etc.
- Spray bitumen within the area marked in the surface uniformly and in the required amount.
- Do not let people and traffic enter the surface where binder has been sprayed.
- Scatter pebbles on the surface immediately after spraying the binder.
- Immediately run roller in the areas where pebbles have been spread.
- Normally rolling is completed in five passes; use pneumatic or light roller for this.
- Gradually open the road to traffic after removing the security barriers and indicator signs and erecting speed limit signs.
- From the second day onwards, remove the pebbles not held by binder by lightly sweeping with a broom.
- Scatter coarse sand in places that are bleeding.
- After removing loose pebbles from the surface and scattering coarse sand in places that are bleeding in this manner for a day or two, surface dressing is done.
- In respect of double bituminious surface dressing, another coat is applied by repeating the above process.

Things to Mind

- Before doing surface dressing, repair and maintenance of patches and potholes should be done.
- Surface dressing is done in a layer or two.
- Surface dressing is normally done over the entire width of the road.
- Surface dressing cannot correct excessive amounts of depression and deformation.

6.2 Slurry Sealing

Why

For the repair and maintenance of various types of cracks seen on the surface of a blacktopped road, free-flowing slurry made by mixing bitumen emulsion, fine pebbles, mineral filler and water is used. This process of repair and maintenance is called slurry sealing. Slurry effectively seals the cracks seen on the road surface by entering them.

How

- Before doing slurry sealing, carry out repair and maintenance, including of potholes and patches.
- Keep the road surface where slurry sealing is to be done clean and dry.
- Do slurry sealing when the weather is good.
- Before starting work, make arrangements for necessary materials, machines, tools and workers at the site.
- Clean the road surface either with a broom or, if possible, with compressed air.
- Use the wheel barrow for small quantity, concrete mixture for medium quantity and special mixture for large quantity as per the quantity of slurry needed.
- Erect indicator signs and security barriers at necessary places and in required number for the safety of workers, machines, tools and work.
- As far as possible, at a stage, do slurry sealing in one lane and open the other lane to traffic.
- Make slurry that is of creamy texture, free-flowing and of a consistency that can sieve through cracks.
- Sprinkle slurry on the road surface and moved ahead by filling up cracks by spreading it with a broom and squeegee.
- Carry out compaction of the road that has light traffic with a rubber tyre pneumatic roller.
- Before opening the road to traffic, let it cure properly.
- Open the road to traffic after removing the security barriers and indicator signs.
- Do slurry sealing of the remaining lane by repeating the above process.

Things to Mind

- Slurry sealing is particularly useful for old blacktopped surface.
- The pebbles to be used for slurry sealing should not normally exceed 6 mm in size.
- Sometimes pebbles up to 10 mm in size are used.
- After making slurry by mixing it with emulsion, it is spread on the road surface either manually or through drag spreaders.
- After spreading the slurry, compaction usually takes places with the weight of the traffic.
- On roads with light traffic, compaction should be done with a rubber tyre pneumatic roller.

6.3 Sand Sealing

Why

Sand sealing is done to enhance the resistance of the road surface against the abrasive action of traffic and to make it impermeable to water so that it doesn't rapidly damage itself.

How

- Erect indicator signs and security barriers.
- Thoroughly clean the surface to be sealed by sweeping or, if necessary, even by scraping it.
- Make the surface dry. Do not do sand sealing if the surface is wet or if the weather is not suitable.
- Mix sand and bitumen in the quantity stipulated in the specification and heat it to the specified temperature.
- Spread the premix uniformly in the required thickness.

- Immediately after this, do compaction with a pneumatic roller or, if it is unavailable, with a steel roller.
- Let the surface set.
- Open the road to traffic after removing security barriers and indicator signs.

Things to Mind

- Sand and bitumen or emulsion are used as primary materials for sand sealing.
- Its thickness is found to vary from 5 to 10 mm.

6.4 Marking of Road

Why

Traffic movement and the effects of weather damage road markings. Information to road users should be kept effective and the chances of accident should be minimized by periodically repairing and maintaining them.

How

- Erect the indicator signs and caution signs on both sides of the work site.
- Ascertain that the road surface is dry and the weather will remain good.
- Remove the dust and dirt on the surface by thoroughly cleaning it and by cleaning the disfigured markings with a hard brush.
- Put the stencils used in the painting work wherever necessary.
- Mix the colour properly and apply it over the stencil.
- As thick coats of paint break easily on drying, pay attention to it.
- If drops of colour fall on the road surface, clean them at once.
- Do not leave the can of colour open.
- Normally, it takes 15 minutes for colour to dry. Make provision for preventing vehicles from driving over the colour until it is dry.
- Make safety arrangements for the painting work and workers (length workers) by taking into account the work progress and the time it takes the colour to dry.
- The painting done towards the end of the day should have dried by the time the labour force returns after removing the security signs.
- Remove the unwanted colours with a blowlamp and scraper, but do not heat the bitumen surface to the point it starts melting.

Things to Mind

- Under the road marking repair and maintanence task, erased and illegible central line, non-overtaking direction line, road edge delineators are restored.
- Re-marking should be done in these spots even after finishing resealing, overlaying and patching work.

6.6 Regravelling of Road Surface

Why

Regravelling of gravelled roads is done when a large number of ruts and depressions appear on them to show their subgrades. This corrects the distortions in the shape of the camber, ruts seen on the surface, and potholes and pits made in the surface.

How

- Make provision for traffic diversion and erect security angles and signs.
- Mark the working area.
- Dig the gravelled surface, spread the gravel and make it compact.
- Sprinkle water on the surface, as needed, add gravel by layers of 15 cm and smoothen it.
- Make every layer compact with a roller. Run the roller from the edge to the centre.
- Check whether the camber on the surface is within 4-6% or not.
- In order to stretch the life of the regravelling, check whether drains and culverts are in good condition or not, and, if they are not, repair and maintain them under an appropriate repair and maintenance title.
- Measure dry density and adjust it as needed.

Things to Mind

- If the surface is excessively damaged, grading should be done before regravelling.
- However, if gravelling has considerably lost its thickness, grading should be avoided.

6.7 Regravelling of Road Shoulders

Why

If the shoulders of the gravelled road have been damaged due to the impact of traffic and weather, or, despite routine repair and maintenance, through deterioration in gravelling due to erosion, potholes, rains and other causes, regravelling is done under periodic repair and maintenance.

How

- As road shoulders are occasionally used by vehicles and continuously by road users, including footpath walkers, repair and maintain them also like the surface for driving vehicles.
- Do regravelling of road shoulders like the regravelling of the road surface; it is described in detail in 6.6 Regravelling of Road Surface.

6.8 Resealing of Road Shoulders

Why

If excessive amounts of crack are seen on the shoulders of a blacktopped road or if pebbles start surfacing due to damage to its surface, resealing should be done.

How

- Do re-sealing by following the process described in Section 6.2 ‘Slurry Sealing’ or 6.3 ‘Sand Sealing’.
- If priming is to be done repeated on a significant length of the road shoulders, do so under periodic repair and maintenance.

6.9 Painting Steel Parts

Why

It is essential to protect the steel parts and other furniture used in road work by painting them periodically. Such parts and other furniture include steel pipes of culverts, railings, steel parts of bridges, various signs, including indicator signs.

How

- Make security arrangements around the work site.
- Remove the dirt, dust, rust and discoloured paint from the surface to be painted by thoroughly cleaning it. This can be done with a wire brush and blower.
- Apply a primer coat with a brush. While applying the primer coat, uniformly apply a thin film over the whole surface without dripping colour. Clean the brush from time to time.
- Let the primer coat dry thoroughly. Normally, it takes 24 hours to dry.
- Apply an intermediate coat, like the primer coat, and let it dry.
- Apply the final coat of colour and let it dry.

6.10 Report

As soon as a job under periodic repair and maintenance is over, a report on it should be submitted in a prescribed format, along with detailed description of the job. A proposal on annual work of periodic repair and maintenance should be prepared and submitted at the beginning of every fiscal year. The feedback on the efficacy of the repair and maintenance work executed in the past, usefulness of the prevalent repair and maintenance working procedure and the improvements that could be introduced in it, along with suggestions, should be made available to the higher authorities. Such reports will make important contributions to introduce timely improvements in the working procedure.

7. Preventive Maintenance

Preventive measures cover laying of nets on the slope, adjusting of the slope by cutting it, scraping of cliffs/ridges, repair and maintenance of machinery and gabion wall, check dam, river training and bioengineering activities such as nursery seeds and seedlings.

7.1 Preventive Repair and Maintenance of Drains

Why

It is essential to carry out periodic inspections and repair and maintenance of catchwater drains and check dams built to protect roads from water flowing from the catchment area to the road and from the road surface to lower slopes.

How

- If the catch water drain is clogged/plugged, clean it and if it is damaged maintain it through repairi and maintenance.
- Repair and maintain the checkdam built to protect the slope from drain erosion, as necessary.
- Before the onset of the rainy season, clean the weep holes in the support wall.

7.2 Repair and Maintenance of Slope

Why

The slope must be repaired and maintained in time to operate traffic on the road. The slope erodes when rainwater accumulates and flows from the slope and when there is too little vegetation in the slope. This covers tasks such as sealing of cracks, dressing, reshaping and cleaning of slopes, netting and bioengineering activities on the slope.

How

- For erosion control, build catch drain; build berms; construct channel drains on embankments; plant grass tufts; carry out netting; grow plants and saplings; and pave stones.
- Stop water from flowing in the slope by constructing a catch drain over the shoulders of the cut face.
- Do not construct the ditch very close to the shoulders of the cut face.
- If the gradient of the road is steep, drip water by using a chute or cascade.
- Build a kerb/channel drain on the outer edge of the road shoulders to prevent erosion of the embankment.

Things to Mind

- The slope can be protected from erosion to some extent by planting grass tufts on them.
- Water should be sprinkled over such places until grass grows.
- To prevent damage to the spot from where grass tufts have been plucked, care must be taken in the selection of area for plucking them and for their necessary protection.
- If the weather and soil are favourable, slope can be protected by scattering grass seeds.
- Construction of a long-lasting and effective ditch requires delineation along the natural contours.
- The outlet of the ditch should be protected by pitching it with stones.
- Repair and maintenance of the ditch should be done regularly after inspecting it during rainy season.
- The repair and maintenance of the slope weakened by landslides around the road can be done by decreasing its angle; clearing the stones/rocks and earth carried by the landslide and disposing it of at a safe place; building a support wall of gabion, masonry, cribwork, concrete and other materials; and by doing netting work in the slope. This helps arrest slope erosion caused by dripping of water during rains and makes moisture available to the grasses, and plants and saplings.
- In addition, when the jute netting rots, plants and saplings get manure.

7.3 Repair and Maintenance of Support Wall

Why

In all types of road, masonry walls and gabion are used for supporting the road and protecting the slope. The damage to such support walls should be inspected periodically and preventive repair and maintenance carried out.

How

- If the back-fill of the support wall has caved in, it should be filled with an appropriate material and campaction done with a rammer/hammerhead.
- If the base of the support wall is being scoured by water, its causes should be identified and appropriate provisions made for preventing it.
- Drain the water flowing into the base of the support wall or make gabion mattress, stone pitching or masonry apron in the base, as needed.
- If the nets of the gabion box have broken or their knots have come loose, repair and maintain them with gabion wire of appropriate size.

Things to Mind

- Gabion and masonry walls are the main types of support wall constructed in the road area.
- Because gabion walls can be built even by relatively less skilled labour, as it easily drains water and as it is flexible enough not to allow the wall to get damaged from minor slip movements, they are widely used.
- As the gabion wire normally lasts for 15 years, their condition should be thoroughly checked in the course of inspection and repair and maintenance.
- Similarly, masonry walls are built in the spots where strong foundations exist.
- At some places, roadside neighbours have been found to be carrying away stones and wire after cutting wire net.

- In such situations, the damaged gabion boxes should be reconstructed by filling up stones/rocks in new gabion boxes of appropriate size.
- To discourage such activities in the future, coordination should be done with roadside neighbours.
- If the gabion support wall has collapsed, or is likely to collapse, a report should be submitted to the agency concerned for rebuilding it.

7.4 River Training and Repair and Maintenance of Road Protection Structures

Why

Since the number and length of roads passing along river banks are notable in Nepal, river training and road protection structures are widely adopted in such roads. Such roads must be repaired and maintained after inspecting the preventive measures thus introduced from time to time.

How

As the overflow of water in the river in the rainy season can damage the road by dismantling the weak sections of the protective measures, it is necessary to repair and maintain such works before the onset of monsoon.

Similarly, necessary repair and maintenance should be done urgently by regularly inspecting the river training and river bank protection structures throughout the rainy season.

7.5 Repair and Maintenance of Bioengineering

Why

Apart from support wall, various types of bioengineering works are done for the protection of the slope lying above and below the road surface. Since expected slope protection from bioengineering can be achieved only through appropriate repair and maintenance, preventive repair and maintenance is done regularly.

The following tasks fall under preventive repair and maintenance of bioengineering activity:
- Thinning of shrubs and trees
- Pruning of tree branches and twigs
- Repair and maintenance of vegetative structures such as palisades, fascines, brush layers and turfs
- Enrichment of vegetation
- Grubbing of unwanted shrubs and trees

Little Things, Big Deeds!

Bioengineering does not act as tall fences, but makes very important contributions to save the surface from land erosion

How

- If the trees and shrubs planted under the bioengineering activity are very thick, pluck out the unwanted trees and shrubs.
- Trim the branches and twigs that have excessively spread out. This will allow sunlight to penetrate and saplings to grow properly.
- If the sites of vegetative structures such as palisades, fascines, brush layers have to be repaired and maintained after inspecting them every six months, do the repair and maintenance in the monsoon.
- Do the task of enriching grasses and trees and saplings at the centre of the saplings planted earlier or in an empty space of the site.
- Under the task of removal of unwanted shrubs and trees, remove from the site those trees that have dried up or about to fall, trees that obstruct the driver's sight line or traffic, trees that provide surcharge to steep slopes, trees and shrubs that fall under the tree and shrub thinning programme.
- Protect the land around the road by planting multiyear plants and saplings that are available and can be grown locally. This will not only add to the attraction of the road but also prevent land erosion.

Trees planted along the road.

8 Emergency Maintenance

Emergency repair and maintenance covers tasks such as manually or mechanically opening the road, building temporary diversions, emergency protection work to arrest further damage to road, clearing the landslide and covering cracks in the slope.

8.1 Inspection and Reporting

The condition of the road should be inspected immediately after a heavy downpour, windstorm or hurricane. If the road is found closed in the course of an inspection, a report should be prepared by clearly mentioning the following facts:

- Condition of the spots where the road is obstructed
- Nature of obstruction and the tasks to be done urgently to open the traffic
- Expected time and cost of opening the traffic
- Possible alternative routes

The report thus prepared should immediately be presented to the superior officer. As soon as such a report is received, the higher authorities concerned must inform travellers about, among other things, the obstruction of the road, time that would take to open the road and the alternative route that could be used, through a public communication media.

8.2 Repair and Maintenance and Cleaning of Road Surface

Why

This type of emergency repair and maintenance is done to operate traffic by carrying out essential temporary repair and maintenance to immediately open the road to traffic by clearing the landslide and other obstructions on the road surface directly concerned with traffic movement.

How

- Give high priority to the task of opening the traffic under emergency repair and maintenance.
- Before starting emergency work, erect temporary road barriers and traffic signs on both lanes of the obstructed road section to inform motor drivers.
- Provide information on alternative route available as far as possible.
- In the course of emergency repair and maintenance, first and foremost, clear the landslide to open the road.
- After clearing the landslide, open the road to traffic by carrying out temporary repair and maintenance of the damage caused to the road surface.

Things to Mind

- If the landslide is still active, it is essential to erect caution signs to protect vehicles and passengers from loss.
- Occasionally, vehicles meet with accidents on the carriageway, obstructing traffic.
- In case the road is closed or obstructed due to such damaged vehicles, as soon as necessary police examinations are over, such vehicles should be moved to the side and traffic opened.
- Necessary arrangements must be made to not allow any vehicle damaged in an accident to obstruct traffic on the road and obstruct traffic operation for a long time in any condition.

8.3 Repair and Maintenance of Embankment

Why

If traffic is disrupted, or if the possibility of its being closed increases, due to damage to the embankment from a flood, landslide or any other cause, it should immediately be repaired and maintained under emergency work.

How

- If there is a possibility of the closure of the road due to an embankment damaged by river erosion, first and foremost, do not let the flow of the river to cause further damage and then divert it far away.
- After diverting the flow by making provision for river control and training work, make provision for smooth operation of the traffic by carrying out minimal necessary repair and maintenance of the embankment damaged by the breach.
- If obstruction is caused to traffic through damage to the embankment due to instability of the slope, immediately give priority to diverting water and preventing further damage to the embankment. If if is not possible to operate traffic on the carriageway, immediately operate traffic by widening the carriage to the minimum width with dry stones, gabion boxes, etc in a temporary manner.
- In case cracks are made in the embankment, water can enter through them and cause additional damage, to prevent this, it is necessary to immediately fill up cracks, drip water to prevent water from entering and cover cracks with an impervious material.

Things to Mind

- The repair and maintenance to be done under emergency repair and maintenance shall be of temporary nature and with the primary objective of immediately opening the road.
- After the emergency situation has subsided, the process should be initiated for repair and maintenance after carrying out a detailed inspection.

8.4 Repair and Maintenance of Cut Slope

Why

If traffic is obstructed, or is likely to be obstructed, due to cracks in the cut slope or due to damage to the cut slope through the collapse of a drain or support wall, it should immediately be repaired and maintained under emergency work.

How

- Fill or cover the cracks seen in the cut slope to prevent water from flowing into them.
- If water flows over the slope due to clogging of the catch drain, the slope should be immediately cleaned for its protection. If the slope has started caving in due to damage to the support wall, it should be protected from further damage by clearing the overburden and building makeshift toe wall or support wall.

8.5 Diversion Construction

Why

If any part of a bridge or road has collapsed, preventing vehicles from driving over them, the road is immediately opened by constructing a diversion under emergency repair and maintenance.

How

- There should be no objection if the geometry and surface of the diversion are of low quality, but do make provision for preventing accidents by erecting adequate number of caution signs and speed limit signs and by building speedbreakers.
- Give prior notice about the closure of the road to traffic by erecting adequate number of obstruction and indicator signs on the damaged portion of the main road.
- Minimize the chances of accident by making available adequate information, including to the transportation vehicles driving at night.
- If it is not possible to open the road or build diversion on a bridge or road section that has collapsed by immediately carrying out repair and maintenance, operate traffic by building makeshift bridges. For this purpose, bailey panels could be an appropriate solution.
- Apart from this, try to build bridges of wood, concrete poles, concrete pipes or any other local materials, if possible.
- If makeshift bridges are to be built, ensure full security.
- In addition, make appropriate provision for traffic signs, security barriers for traffic operation and lights, if available.

8.6 Traffic Management in Emergency Situations

Why

The vehicles that are waiting due to closure of road because of floods, landslides or any other natural calamity exert pressure to immediately open the road. In such a situation, emergency work has to be executed by paying special attention to traffic management.

How

- If the road is closed, or might be closed soon, inform road users about it as soon as possible.
- Reduce pressure by effectively disseminating information, including on an alternative route, through the communication media.
- If the road is closed, indicator signs should be erected in adequate number to provide information about it.
- Provide advance notice to stop vehicles by erecting indicator signs at necessary distance in order to reduce congestion at the site of work, thus enabling making of proper security

arrangements. Similarly, if it is possible to operate traffic only on one lane, do so even by taking the help of the traffic police and by making provision for adequate number of signs, lights and watchmen.

- Collect records on road closure and send them to the higher authorities. Such reports on road closure help execute emergency work and formulate plans for the coming years.

8.7 Emergency Repair and Maintenance of Bridges and Culverts

Why

if the bridge or culvert is so damaged that traffic cannot drive over it or if it is not repaired and maintained so that the traffic will have to be closed, emergency repair and maintenance should be carried out with high priority.

How

- If the waterway of the bridge or culvert is nearly choked with branches and twigs, weeds and stones and pebbles, immediately clean and open it.
- If traffic can drive only on one lane of the bridge or culvert, do so after making traffic arrangements by making full provision of security by erecting necessary signs, security signs, barriers, lights and posting flagmen.
- If it is not possible to operate traffic over the bridge or culvert, or if it seems risky to do so, operate traffic, if possible, by building temporary crossings or, if it is not possible, by making a diversion, after making security provision by erecting barriers and light. Such barriers should be of adequate strength.
- While operating traffic on a diversion, make special provision for security for night. Make provision for smooth transition at the entrance to the diversion as well as for preventing dust nuisance and for allowing adequate visibility. For the safety of the vehicles and passengers using the diversion, erect indicator signs, guide posts, etc on the shoulders of diversions and, as far as possible, make provision for light throughout the night. If only one-lane diversion can be built, make provision for flagmen and, if possible, for traffic police on both sides, considering the importance of the road and traffic density.
- Prevent accidents and further damage to security barriers, railings, parapets, etc that are about to collapse due to an accident, natural calamity or any other cause by repairing and maintaining them with priority.

Things to Mind

If traffic is obstructed by a damaged bridge or culvert, a notice about it should be erected on both sides of the damaged road at a necessary distance. Apart from it, the traffic closure form should be filled up and submitted to the higher authorities as soon as possible in order to inform road users about the obstruction. Reporting, including a detailed description of the damage and a factsheet about the task to be done for emergency work, helps plan, implement and evaluate the emergency and rehabilitation work.

Some Important Facts

- The cost of 25 bulldozers is equivalent to 5 million workdays for constructing a rural road based on people's labour. This also includes the cost of hand tools.
- It takes 10 groups of 15 labours each five months to finish the job done by a bulldozer in a month. This provides long-term employment to the labour.
- VDCs are ready to spend money for the bulldozer, but hesitate to spend money for repair of the road. This shows low awareness of the advantages of labour-intensive construction as well as lack of knowledge of the importance of simple road construction. Hence, it is extremely important to continuously build awareness of labour-intensive construction work.
- Even if a machine has to be used, an excavator would be more appropriate than a bulldozer.
- Because it is multipurpose, and, along with cutting, it can also easily do the work of filling up earth. This reinforces the stability of the *pakho* that has been eroded through breaching during the road construction work (since it is possible to fill up half of it with that). If bulldozer must be used, it can be done by leasing it considering the nature of work, and not by the local agency buying it by investing a lot of money. The practice of leasing for the right task would be very beneficial.