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MINISTRY OF RURAL DEVELOPMENT

RURAL ROAD MAINTENANCE TRAINING MODULES FOR FIELD ENGINEERS

Module-1
INTRODUCTION

Ministry of Rural Development

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Module-1

Introduction

This training module is produced through a collaborative effort between the International Labour Organization and the National Rural Road Development Agency under the technical assistance component of the World Bank supported Rural Roads Project-II of Pradhan Mantri Gram Sadak Yojana Project (PMGSY).

Contents:

- Introduction to maintenance of road works
- Classification of maintenance works
- Road components and terminology
- Standard design for rural roads

Learning Objective:

At the end of this Module you are expected:

- To know why maintenance is important
- To know classification of road maintenance
- To know each components of the road
- To know the standards applicable for rural road maintenance works

Acknowledgement

The following publications were also used as reference materials:

- Managing Maintenance of Rural Roads in India, ILO/NRRDA, January 2015
- Team-based maintenance of rural roads – Conceptual guide, Serge Cartier van Dissel, ILO Office in Nepal and Employment Intensive Investment Programme (EIIP), International Labour Organisation, 2009

Foreword

Pradhan Mantri Gram Sadak Yojana (PMGSY), was launched in December, 2000 as a special intervention of the Government of India with the broad objective of ensuring sustainable poverty reduction. The scheme aims to provide good quality all-weather single connectivity to every eligible habitation. Rural roads are a state subject under the Constitution and as such are the basic responsibility of the states. However under the PMGSY, the construction of good quality and well-engineered roads are fully funded by the central government. Maintenance of these roads is the responsibility of the states. The year 2013 saw the launch of PMGSY-II with the objectives of consolidating the existing rural road network and upgrading existing rural roads that provide connectivity to rural growth centres. PMGSY-II envisages sharing of construction costs between the Centre and the states with maintenance costs continuing to be funded fully by the states.

Over the last 14 years, the PMGSY has carved out a place for itself as a programme characterised by creation of good quality assets, effective management and technical proficiency by the National Rural Road Development Agency (NRRDA), along with capable state road agencies. For implementation and operations, the involved agencies have been supported with detailed documentation in the form of programme guidelines, an operations manual, standard bidding documents, specifications, a standard data book, a procurement and contracts management manual and the Quality Assurance Hand Book with support from the Indian Roads Congress. These documents have also contributed significantly towards effective implementation of PMGSY and even for mainstreaming good practices in other rural roads programmes being executed by the states from their own resources.

An area of concern has been lack of regular maintenance as per the “Programme Guidelines”. However, in recent years, there has been increased awareness and commitment to maintenance by the states. The tempo needs to be sustained and further accelerated.

Under the technical assistance component of the World Bank supported Rural Roads Project-II, the International Labour Organization (ILO), in collaboration with NRRDA has prepared a manual “Managing Maintenance of Rural Roads in India”. This initiated the execution of maintenance works and the development of these training modules for engineers and contractors associated with rural road maintenance works. To strengthen such activities in the participating states of RRP-II, a series of training of trainers workshops were arranged at national and state level based on the course material developed.

The training modules broadly cover the principles for maintenance management of rural roads, planning and execution of common maintenance interventions to ensure reliable transport services and safety to users and the local communities served by the rural roads, and arrangements for monitoring the performance of contractors engaged for the task.

I would like to acknowledge the support of all those associated with the development of these training modules, especially the ILO and its technical assistance team, Mr. Htun Hlaing, Mr. Bjorn Johannessen and the project's Rural Roads Maintenance Engineers. I would also place on record the valuable suggestions of my colleagues Ms. Manju Rajpal, IAS, (ex Director – RC), Mr. R. Basavaraja, Director NRRDA, Mr. S. S. Bhatia, Deputy Director, NRRDA, Mr. A. K. Sharma, Consultant World Bank and senior engineers as well as secretaries from State Governments in bringing the document to its present shape.

I sincerely believe, the training modules would be found useful for the states in their efforts to secure adequate maintenance of all rural roads, not merely the PMGSY roads and improve maintenance practices so that benefits of access continue to remain available for our rural people on a sustainable basis.

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October, 2015

1

Introduction to Training Modules

The purpose of this training manual is to provide technical management staff and contractors with appropriate guidelines for the effective management of road maintenance works. The training modules are based on the manual "Managing Maintenance of Rural Roads in India". These modules broadly cover the principles for maintenance management of rural roads, planning and execution of common maintenance interventions to ensure reliable transport services and safety to users and the local communities served by the rural roads. The arrangements for monitoring the performance of contractors engaged for the task are also covered in these modules.

This manual is broken down into the following categories composed of different modules:

Module 1: INTRODUCTION

Module 2: TECHNICAL CONSIDERATIONS AND IMPLEMENTATION ARRANGEMENTS

Module 3: FINANCING RURAL ROAD MAINTENANCE

Module 4: PLANNING, INSPECTION, REPORTING AND MONITORING

Module 5: APPROPRIATE SETTING OUT TECHNIQUES

Module 6: HAND TOOLS, EQUIPMENT & CONSTRUCTION MATERIALS

Module 7: ROUTINE MAINTENANCE WORK METHODS

Module 8: OCCUPATIONAL HEALTH & SAFETY, ENVIRONMENTAL ISSUES AND DECENT WORK

Module 9: CONTRACT MANAGEMENT

The trainer may decide to conduct a full course consisting of all the nine modules or may selectively conduct specific modules depending on the needs of the target group.

As a general advice the trainer should:

- **Encourage active participation**

  There is sometimes a tendency of the trainer to act like a teacher in school and to read or lecture directly from the course material. This behaviour should be avoided. Trainees remember information better if they participate actively in discussions and if there is a free exchange of views and of questions between everyone participating in the course.

- **Guiding the discussion**

  There are times during a discussion when everyone wants to speak at the same time. When such situations arise, the trainer should insist that the group listen to one person at the time. If one speaker hijacks the floor too long, the trainer needs to interrupt, pointing out that other participants may also want to speak.

- **Listen attentively**

  Equal attention should be paid to each speaker. Listen attentively and let the speaker understand that ideas and opinions expressed are both interesting and relevant. It is sometimes useful to take a brief note of participants' suggestions while they are speaking, noting them down on a flipchart or blackboard. A summary of these notes may prove useful for later discussions.

- **Emphasise important points**

  Each time the participants make an important point or expresses an interesting opinion, the trainer should draw the group's attention to it by repeating the idea in simple terms which are understood by the majority of the trainees.

- **Preparing the sessions**

  When trainees only listen to a description of how a particular job should be done, they are likely to forget what they heard. If however, they actually carry out the task concerned, they will remember how to do it. For this reason, every effort should be made to include as many practical exercises and demonstrations as possible, be they carried out on the worksite or in the training room. Practical sessions should always be carefully planned in advance.

- **Recapping**

  A discussion is more than just a conversation. A subject is discussed with an aim in mind. It may occasionally be worthwhile recapping the topic considered and recalling the aim of the discussion by intervening from time to time to give a brief summary of the main points dealt with so far.

- **Questioning**

  An important role of the trainer is to ensure that the atmosphere during training is sufficiently relaxed to allow participants to feel at ease to speak freely. Questions set by the trainer should not be regarded by the trainees as tests. Often there is no strict "right or wrong" answer to a question, except for mathematics. Questions should simply give your trainees the opportunity to put forward their individual points of view.

Table of Contents

1 Introduction

1.1 PURPOSE OF MAINTENANCE

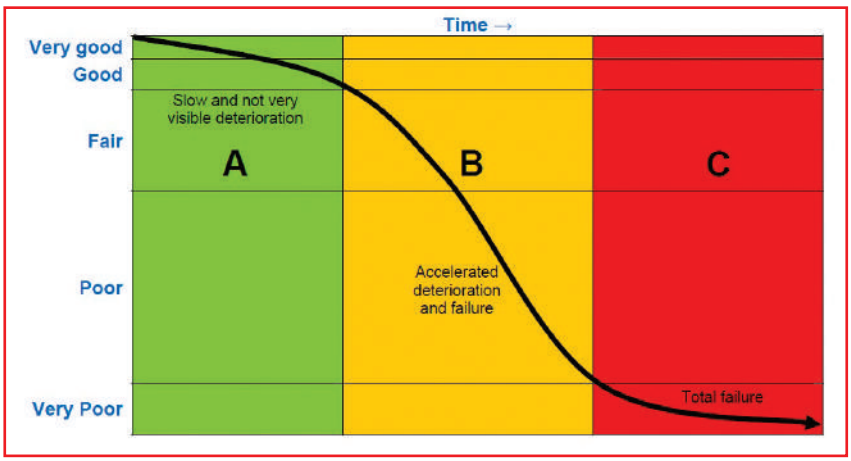
The basic objective of road maintenance is implicit in the word itself. It is done to ensure that the road that has been constructed, rehabilitated or improved, is to the extent possible kept in its original condition. All roads require maintenance as they are subjected to traffic and the forces of weather. Even with the highest possible quality of construction, maintenance is essential to get optimum service from the road structure during its life period. By applying preventive maintenance, the deterioration of the road and its components can be slowed down, thus postponing the need for costly investments in rehabilitation and securing the planned design life.

Definition

The Indian Roads Congress defines road maintenance as "routine work performed to upkeep pavement, shoulders and other facilities provided for road users, as nearly as possible in their constructed conditions under normal conditions of traffic and forces of nature". Maintenance is "essential to get optimum service from the pavement structure during its life period."

Road deterioration is generally slow at first and not very visible, taking the form of wear and tear and minor damage to the road surface and the drainage system (see phase A in Figure 1). Because the damage to the road is minimum the road user tends not to make a fuss on the deterioration, despite the gradual increase of isolated minor failures. As a result of no maintenance intervention, the road deteriorates from a very good to a fair condition. At this time the rate of deterioration tends to increase, as the road base and

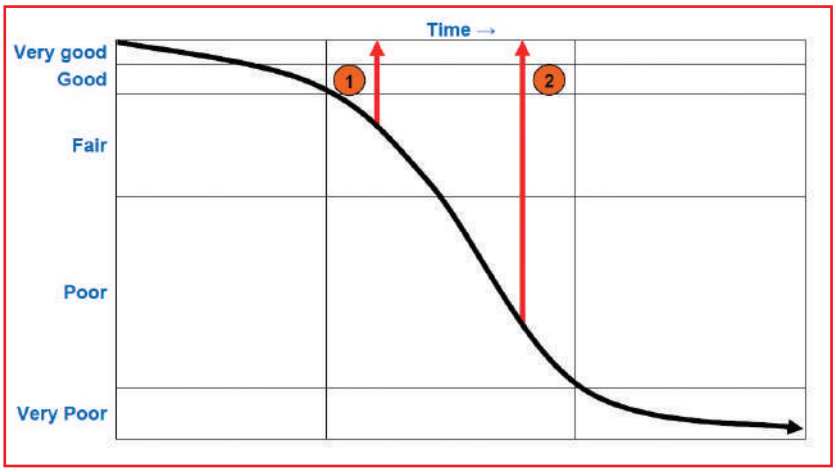
Figure 1: *Illustration of deterioration effects on a non-maintained road*



the foundations of the physical road structures start to become affected (Figure 1 phase B). This is especially due to water, which is no longer guided safely away from the road as a result of deterioration of the carriageway, shoulders and other drainage system, and thus damaging and weakening the road and making it more susceptible to damage by traffic. Although the damage to the road can be observed at various scattered locations at the beginning of this phase, it spreads out until the entire road can be said to be in poor condition. Once the road condition has become very poor, the deterioration tends to decrease, as traffic levels goes down severely, and because there is little left to deteriorate (Figure 1 phase C).

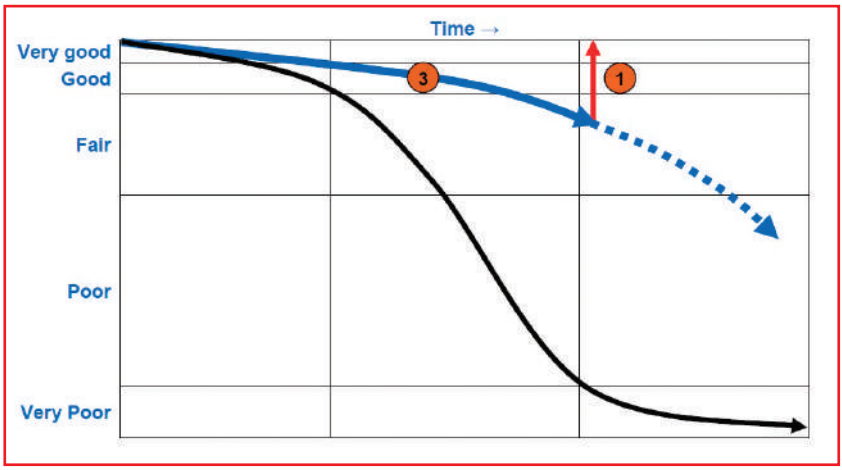
The condition of the road can be improved by carrying out corrective maintenance. Repairs are made to the road surface and shoulder, the drainage system and other physical road structures. The more deteriorated the road is, the more intensive and thus costly the repairs will be (Figure 2). For instance, corrective maintenance when the road is still in good or fair condition (Figure 2 arrow 1) may entail patching potholes and minor repairs to the drainage system and other road structures. However corrective maintenance carried out once the road is already in poor condition (Figure 2 arrow 2), is likely to entail complete resurfacing and possible reconstruction of the road base. The distance from the line (in black colour) indicating the road condition, to the desired good or very good condition of the road is therefore indicative of the level of corrective maintenance required and thus for the cost of this maintenance.

Figure 2: *Illustration of corrective maintenance cost*



By carrying out regular routine maintenance the deterioration of the road is slowed down considerably, as can be seen in the blue line (line 3) in Figure 3. Consequently, the corrective maintenance is required less frequently (Figure 3 arrow 1) leading to reduced overall maintenance costs, and the road is generally in better condition, resulting in lower travel times and costs.

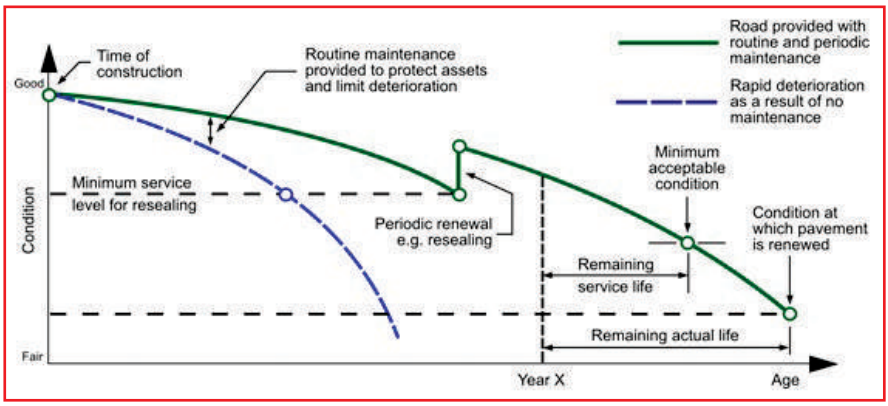
Figure 3: *Illustration of the effects if routine maintenance is implemented*



The need for maintenance depends upon a number of external factors such as traffic, terrain, soil types and climate. It is also very much determined by the original technical designs applied and the quality of the works when the road was constructed. Depending on these parameters, it is possible to devise maintenance solutions and corresponding management systems that optimise maintenance costs and efforts. To make the most out of available funding, emphasis should always be on preventive measures in the planning and management of road maintenance. In terms of non-emergency related works, experience clearly shows that it is the regular or routine maintenance activities related to preserving the drainage system which have the most significant effect in terms of extending the lifetime of a rural road as shown in Figure 4. Most of these works do not involve any sophisticated technology or skills, can be carried out using manual labour and simple hand tools, and are inexpensive.

As shown in Figure 4, providing routine and periodic maintenance in a planned manner has a significant impact in terms of achieving an extended service life

Figure 4: *Effects of maintenance on road design life*



of a road. The periodic maintenance, e.g. resurfacing, is equally important, but on a different time scale with longer cycles in terms of years rather than months. Depending on the performance of the pavement, there may be several cycles of periodic maintenance works on the road before its service life is exhausted.

The above figure also clearly shows that if routine maintenance is not provided, it advances the point of time when periodic maintenance is required. The experience actually show that on rural roads where basic access is the main priority, the point at which periodic maintenance is performed can be further delayed if the routine maintenance levels are increased (also linked to the defined service levels). However, at a certain point of time, periodic maintenance will eventually be required since the maintenance challenges become too large to be effectively dealt with through routine maintenance interventions. Beyond a certain stage, the road becomes "unmaintainable" and runs the risk of returning to the vicious cycle in which substantial rehabilitation works are once more required. Periodic maintenance is therefore also in effect preventive although the operations are reactive in nature, i.e. triggered by a condition level where corrective actions are required.

Maintenance ensures that the road remains serviceable throughout its design life. Maintenance is important because it:

- Prolongs the life of the road by reducing the rate of deterioration, thereby safeguarding previous investments in construction and rehabilitation,
- Lowers the cost of operating vehicles on the road by providing a smooth running surface,

Breaking a vicious circle

Without an organised approach to preserving the road network, it is often seen that road works agencies are forced into a situation of consistently dealing with the effects of the lack of maintenance, having to repair and reconstruct road sections that have failed since timely and adequate maintenance interventions were not carried out.

For obvious reasons, the first priority is to keep all roads open throughout the year (accepting that some road sections are not passable during extreme weather conditions). Without a preventive maintenance system in place, the efforts to keep roads open very much consists of carrying out repairs after serious damage has taken place. Such interventions are much more costly than preventive maintenance. Due to the extent of damages each year, the remedial works often drain the entire road works budgets, leaving no resources left for preventive measures.

With the damages taking place during the previous rainy season, road agencies are left with no alternative than to use subsequent budgets to once again repair serious damages to its roads. Although these repairs are necessary, it is obvious that this way of managing the road network is costly and ineffective. The only way of breaking this vicious circle is to introduce the concept of preventive maintenance, thus reducing the extent to which the roads require major repair works. The cost savings in repair works can then be brought forward to the next maintenance season and instead utilise for further preventive activities that may preserve the road assets.

- Improves the reliability of the road allowing it to remain open for traffic on a continuous basis and thus contributes to more reliable transport services, and
- Sustains social and economic benefits of improved road access.

The first purpose is primarily in the interest of the responsible government authorities. Road agencies need to protect their investments made in improving the road network, thereby maintaining high service levels for the road users. The last three are of more general interest to vehicle operators and the inhabitants of the area serviced by the road.

No matter what technical designs are chosen, all roads, from major highways to local roads, require regular and timely maintenance in order to secure a reasonable lifetime on the construction investment. Attempts to find technical designs that are maintenance-free are disillusions and in the long run only prove that lack of maintenance leads to accelerated rates of deterioration.

It is also important to make a clear distinction between maintenance and repair works. Effective maintenance is clearly time-linked, and to be efficient is carried out before major damages take place. This involves activities relating to supervision and monitoring of the road assets even while they are still in good condition. It also requires that road authorities are sufficiently responsive and capable of taking action when it is required - as opposed to responding with repairs when major damages have taken place or road access has finally been cut off.

Timely and regular maintenance requires securing sufficient funding before repairs and maintenance become an urgent matter. The most effective maintenance is achieved when an organisation is capable and prepared to carry out appropriate interventions at an early stage of deterioration and thus limit the extent of damages. This implies that the responsible authority is furnished with the necessary human and financial resources to effectively manage all facets of the maintenance works.

Rural roads are the last links in transport networks and thus form a critical link in terms of providing access for people living in rural areas. Permanent or seasonal

Figure 5: *Benefits of roads and the importance of maintenance*

absence of road connectivity acts as a crucial factor in terms of denying rural communities access to basic services and economic opportunities.

The social and economic impacts of roads are well established[1]. Communities and local governments often attach a high priority to road improvements. Rural roads improve access to markets, schools, health services and other public amenities. Better access provides the opportunity for increased income and employment opportunities and can also contribute to the alleviation of poverty. Still, maintenance of rural roads is seriously neglected many places.

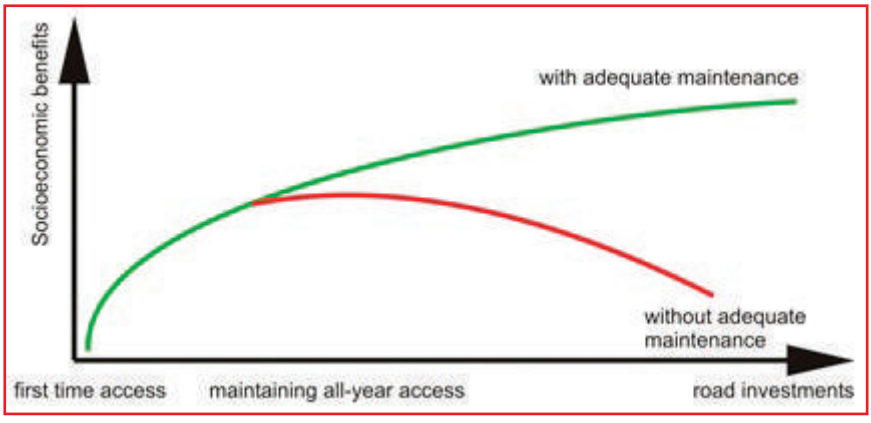
Although the link between rural roads and poverty alleviation is mostly indirect, experience clearly shows that areas with poor road access are generally more disadvantaged than areas that are better served. Investments in rural roads can therefore often be justified from both an economic and a livelihoods improvement point of view. Nevertheless, whatever benefits they provide are short lived if they are not maintained.

Rural roads have in recent years received increased attention, partly due to a growing recognition to its role in poverty reduction. However, it is not the construction of roads that ensures access over time. If roads are not provided with adequate maintenance then their access value will be lost. It is the maintenance applied to roads that provides the sustained access and contributes to the improvement of livelihoods and economic development.

Furthermore, it is only as a result of sustained access through maintenance that builds the confidence required for people to invest in improved farming practices and other business opportunities in the rural areas.

Figure 6 below shows the relationship between investments in road development and socio-economic benefits. It indicates that the initial investments in providing first time access generate the fastest increase in

Figure 6: *Illustration of relationship between road investments and maintenance to socio-economic benefits*

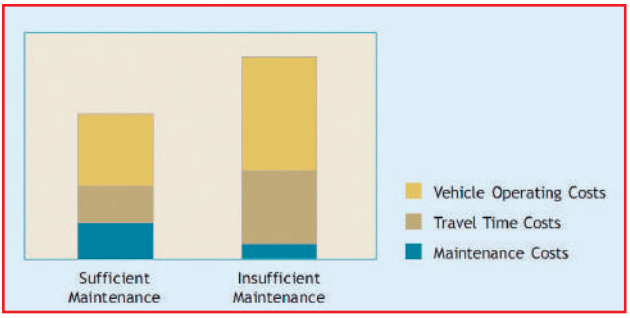


[1]Ref: Rural Road Maintenance - Sustaining the Benefits of Improved Access, ILO Publication, 2007

socio-economic benefits, followed by investments that provide all year access (in areas that only have seasonal access). The smallest increase in socio-economic benefits results from further road improvement and upgrading. Maintenance works sustain and compound the benefits generated, while lack of maintenance results in a significant decrease in socio-economic benefits over time.

Maintenance costs are generally small compared to other direct costs of road travel. The impact of maintenance on vehicle operating cost and travel time cost can be considerable. Figure 7 illustrates the effect on direct transport costs (vehicle operating cost and travel time) of neglecting maintenance.

Figure 7: *Effects of neglecting maintenance of roads*



In addition, with insufficient maintenance, the road will deteriorate and the operation costs for the road will also increase. It needs to be noted that this example does not consider the costs of any negative socio-economic impacts due to a lack of maintenance and a possible negative impact on accidents.

As a result, the preventive action required as part of an effective maintenance system often consists of minor repairs to the drainage system before water causes any major damage to the road assets. If this is not carried out in a timely manner, the pace of deterioration increases, leading to and accelerating increases in rehabilitation costs.

Benefits of Sustained Access

- Owners of vehicles incur lower operation costs and slower depreciation of their vehicles,
- Reduces the cost of operating public transport services,
- Users of public transport benefit from reduced travel times, lower fares, higher frequencies, more regularity of services and better comfort,
- Farmers, entrepreneurs and traders retain access and incur lower transport costs,
- Improves the business environment for farmers and local entrepreneurs,
- Rural dwellers get easier access to health services,
- Children and youth experience easier access to school, resulting in lower drop-out rates,
- Communities as a whole can maintain social and economic ties to the outside world,
- Government agencies achieve better access to local communities in terms of providing outreach services such as health, education, agricultural extension services, etc.,
- Rural areas become more attractive to investors,
- Improved access to employment opportunities and other economic activities,
- Government avoid expenditures in reconstruction and rehabilitation works.

The direct implications of poor maintenance are four fold:

1. Depreciation of the value of the road network;
2. Increasing transport costs;
3. Declining rural access; and
4. Loss of economic development and employment opportunities.

1.2 CLASSIFICATION OF MAINTENANCE

The maintenance of rural roads can be classified into:

(i) Routine maintenance,
(ii) Periodic renewal, and
(iii) Emergency maintenance works.

Maintenance activities are also categorised based on where the works are located:

Off-carriageway works consist of maintaining shoulders and drains, clearing of cross drainage structures, removal of debris, cutting of grass and bushes. The works also include minor repairs to drainage and other structures in the roadside area, maintenance of road signs and pavement markings, side slopes and all surface areas within the road reserve. Off-carriageway maintenance is normally a routine activity.

On-carriageway works relate to road pavement and surface repairs. This work mainly consists of maintaining a good running surface on the road, free from any obstructions and damage and with the necessary camber or cross-fall to secure proper surface drainage.

1.2.1 Routine Maintenance

Every road requires routine maintenance to be carried out once or more to upkeep pavement, shoulders and other facilities provided for road users, as nearly as possible in their constructed condition under normal conditions traffic and forces in nature. These are typically small-scale or simple, but widely dispersed and most can be performed using manual labour. The need for routine maintenance can a degree be estimated and planned and are carried out on regular basis at fixed times during the year.

Figure 8: *Workers performing routine maintenance*

Routine Maintenance activities may further be defined as either cyclic or reactive as stated below.

Cyclic activities are performed at predetermined intervals throughout the year purely as a preventive measure because of events we know will occur (e.g. cleaning of drains before and during seasonal rain fall).

Reactive activities are performed in response to a triggering condition that require action before the problem gets out of hand (e.g. blocked culvert, crack sealing and pothole patching).

1.2.2 Periodic Renewal

Figure 9: *Road surface showing a history of routine maintenance, now due for resealing*

The Periodic Renewals (Periodic Maintenance) consist of the provision of a surfacing layer/ bituminous overlays over the pavement at regular interval of time; so as to preserve the required characteristics of the pavement and offset the wear and tear caused by traffic, weathering etc. Furthermore, the strengthening of pavements and major repairs to damages of drainage structures are also undertaken under periodical renewal works. In effect, periodic renewals represent preventive maintenance which is needed to prevent deterioration of the pavement characteristics and to ensure that initial qualities are kept up for the future requirements of traffic during the design life of the pavement.

Depending upon the traffic levels, pavement type, geographical and climatic conditions periodic renewal works are typically carried out after a period of 5 to 10 years. The work activities involved are normally larger and require more equipment and specialist skills. As a result, this work is considerably more costly and requires more detailed planning. The most common periodic maintenance activities include renewal works such as bituminous overlays, strengthening of pavements and major repairs of damaged drainage structures. As such, periodic renewal works are more costly and requires more detailed planning.

1.2.3 Emergency Maintenance

Emergency maintenance responds to occasional, unforeseen events such as landslides, washouts, large trees or debris on the road and broken

drainage structures. Such damages require immediate attention in order to keep the road open, secure the stability of the road/or to ensure the safety of the road users. Emergency maintenance can be categorised into (i) temporary restoration works, re-opening safe passage on the road, and (ii) permanent restoration, securing the stability of the road and reinstating all its components to its former (or a better) condition.

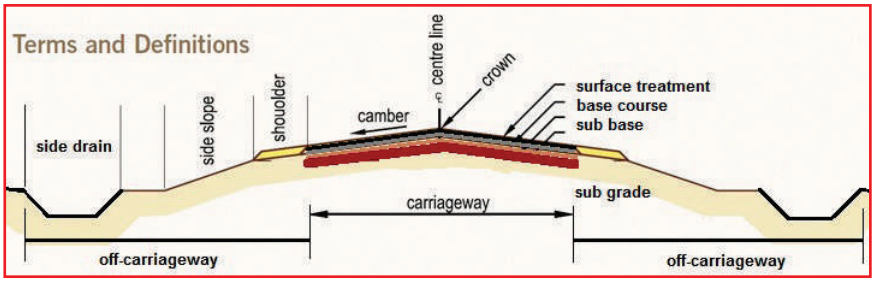
Figure 10: *Emergency maintenance required for landslide*

While taking up immediate action for the emergency situations as stated above, priority should be given to such activities that ensures to keep the road (even partially) passable. For example, disruption of passage of traffic may happen, if a broken culvert is not attended immediately. While a landslide which covers part of carriageway allowing the traffic to pass the affected section, remedial action is still required to clear the full width of the road and remove all debris from the drainage system. So, regular inspection and taking proper action to prevent disruption of traffic, particularly during the period of heavy rains is of utmost importance.

1.3 ROAD COMPONENTS

Below are the most common road components and terminology used in road works.

Figure 11: *Typical road components*



Roadway: Width of the road normally used by traffic, consisting of shoulders and carriageway.

Carriageway: The portion of road, intended for use by vehicles but excluding shoulders.

Off-carriageway: The portion of road component starting from shoulder up to back slope of the drain.

Centre line: The theoretical line running along the longitudinal axis (middle) of the road.

Camber (cross-fall): The lateral slope(s) on the road from the centreline to the shoulder break point, constructed to drain rainwater from the carriageway to the side drain.

Crown: The highest point on the road cambered carriageway, usually on the road centreline.

Cut Slope: The constructed inclined soil surface in a cut.

Side Cut: Excavation of the natural soil to construct the road to its designed cross section and level. The excavated soil may be used elsewhere for construction (cut to fill) or disposed of outside the formation area (cut to spoil).

Side Drain: The function of road side drain is to collect surface water from the roadway and lead it to an outlet.

Shoulders: Unpaved edges of the roadway, between the edge of the carriageway and the shoulder break point. The shoulder provides side support for the pavement or gravel surface and allows vehicles to stop or pass in an emergency.

Embankment: Constructed and compacted soil base-course (or sub-base course) fill below the roadway and the natural ground level.

Embankment/Side slope: The side slope of the embankment, usually constructed at 1:2.

Formation level: The top of the subgrade.

Formation width: Full width of the road, including drains and embankments.

Wearing course: The layer of compacted gravel or sealed surface on the carriageway, which supports the traffic load.

Base course: Is the immediate course below the wearing course and is the medium through which the stress imposed from the traffic load are distributed evenly.

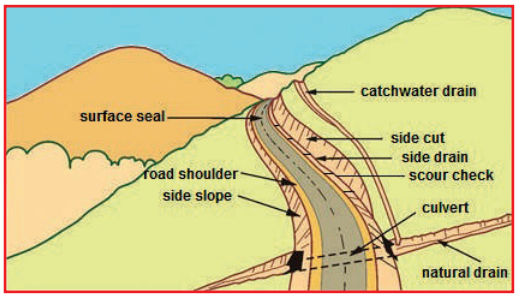
Sub-based course: The layer below the base course which provides additional help in distributing the loads.

Sub-grade: The compacted natural earth immediately below the payment layer.

Catchwater drain: Catch water drain is a ditch constructed on the uphill side designed to intercept or collect and drain away surface runoff water flowing towards the road from the uphill side, and lead it to a suitable point of disposal.

Culvert: A drainage structure allowing water to pass under the road to be discharged on the lower side of the road.

Figure 12: *Drainage components*



Mitre Drain: Mitre drain leads the water out of the side drains and safely disperses it onto adjoining land.

Scour Check: Scour check is a small structure placed across the drain on steep gradients and is designed to slow down the flow of water to prevent erosion of drain invert and slopes.

Super elevation: Inward tilt or transverse inclination given to the cross-section of a carriageway throughout the length of a horizontal curve to reduce the effects of centrifugal forces on a moving vehicle. Super elevation is expressed as a percentage.

1.4 RURAL ROADS STANDARDS

It is important to be aware of the standard design standards used in rural road works to give guidance to the maintenance work. These Guidelines relating to geometric design standards are intended to be applied to rural roads. For these guidelines, the rural roads shall include Other District Roads (ODR) and Village Roads (VR).

1.4.1 Terrain Classification

The general slope of the country classifies the terrain across the area. The terrain is an important parameter governing the geometric standards and the criteria are given in Table 1.

Table 1: *Terrain classification*

Terrain Classification	Cross Slope of the Terrain	
Plain	0 ~ 10 %	More than 1 in 10
Rolling	10 ~ 25 %	1 in 10 to 1 in 4
Mountainous	25 ~ 60 %	1 in 4 to 1 in 1.67
Steep	Greater than 60%	More than 1 in 1.67

1.4.2 Design Speed

Design speed is a basic criterion for determining all geometric features of horizontal and vertical alignments.

Table 2: *Design speed for rural roads*

Road Classification	Design Speed (km/h)							
	Plain Terrain		Rolling Terrain		Mountainous Terrain		Steep Terrain	
	Ruling	Minimum	Ruling	Minimum	Ruling	Minimum	Ruling	Minimum
Rural Roads (ODR and VR)	50	40	40	35	25	20	25	20

1.4.3 Road Land Width

Road land width (also termed as Right-of-Way) is the width of land acquired for road purposes.

Table 3: *Recommended road land width*

Road Classification	Plain and Rolling Terrain				Mountainous and Steep Terrain			
	Open Area		Built-up Area		Open Area		Built-up Area	
	Normal	Range	Normal	Range	Normal	Range	Normal	Range
Rural Roads (ODR and VR)	15 m	15~25 m	15 m	15~20 m	12 m	12 m	12 m	9 m

The lower value of land width may be adopted where the traffic intensity is less than 100 vehicles per day, and where the traffic is not likely to increase due to the situation, like, dead end, low habitation and difficult terrain condition.

1.4.4 Roadway Width

Roadway width inclusive of parapet, side drain for rural roads in different terrain shall be as per Table 4.

Table 4: *Recommended road width for different terrain classification*

Terrain Classification	Roadway Width
Plain and Rolling	7.5 m
Mountainous and Steep	6.0 m

For rural roads, where the traffic intensity is less than 100 vehicles per day, and where the traffic is not likely to increase, the roadway width may be reduced to 6.0m in case of plain and rolling terrain.

The roadway width for rural roads is on the basis of a single lane carriageway of 3.75m.

On horizontal curves the roadway width should be increased corresponding to the extra width of carriageway for curvature.

On roads subjected to heavy snowfall and landslides, where regular snow and debris clearance is done over long period to keep the road open to traffic, roadway width may be increased by 1.5m.

1.4.5 Carriageway Width

For rural roads, the carriageway width may be restricted to 3.0m, where the traffic intensity is less than 100 vehicles per day and where the traffic is not likely to increase.

Table 5: *Recommended carriageway width*

Road Classification	Carriageway Width	Remarks
Rural Roads (ODR and VR)	3.75 m	3m if traffic intensity is less than 100 vehicles per day

1.4.6 Camber

The camber on straight section of road be as per Table 6.

Table 6: *Camber for different road surfacing*

Surface Type	Camber (percent)	
	Low Rainfall (Annual Rainfall<1000mm)	High Rainfall (Annual Rainfall>1000mm)
Earth Road	4%	5%
WBM and Gravel Road	3.5%	4%
Thin Bituminous Pavement	3%	3.5%
Rigid Pavement	2%	2.5%

1.4.7 Side Slopes

Side slopes for rural roads where embankment height is less than 3.0m is given in Table 7.

Table 7: *Side slopes for rural roads*

Condition	Slope (H:V)
Embankment in silty/sandy/gravelly soil	2 : 1
Embankment in clay or clayey silt or inundated condition	2.5 : 1 to 3 : 1
Cutting in silty/sandy/gravelly soil	1 : 1 to 0.5 : 1
Cutting in disintegrated rock or conglomerate	0.5 : 1 to 0.25 : 1
Cutting in soft rock like shale	0.25 : 1 to 0.12 : 1
Cutting in medium rock like sandstone, phyllite	0.08 : 1 to 0.06 : 1
Cutting in hard rock like quartzite, granite	Near vertical

1.4.8 Scour Checks

Instalment of scour checks provides an efficient method for reducing soil erosion in side drains in hilly terrains. The interval will depend on the gradient of the drain and the type of soil. Steep gradient will require more frequent scour checks while in sandy soil condition more score checks need to be installed.

Table 8: *Scour check interval*

Drain gradient	4%	5%	6%	7%	8%	9%	10%	>10%
Scour Check interval	Not required	20m	15m	10m	8m	7m	6m	Lining of drain is required

1.4.9 Cross Drainage Structures

The roadway width at drainage crossing shall be as given in Table 9.

Table 9: *Road width at drainage structures*

Road Classification	Type of Drainage Structure	Terrain Type		Remarks
		Plain and Rolling	Mountainous or Steep	
Rural Roads (ODR and VR)	Culvert	7.5 m	6.0 m	Measured from outside to outside of the parapet walls
	Causeway and Submersible Bridge	7.5 m	6.0 m	
	Bridge	5.5 m		Measured between the kerb for bridges

1.4.10 Widening at Curves

At sharp horizontal curves, it is necessary to widen the carriageway to facilitate safe passage of vehicles.

Table 10: *Widening of carriageway at curves*

Radius of Curve (m)	Up to 20	21 ~ 40	Above 40
Extra widening for 3.75m wide single lane carriageway	0.9 m	0.6 m	Nil

Notes

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