



सत्यमेव जयते

MINISTRY OF RURAL DEVELOPMENT

RURAL ROAD MAINTENANCE TRAINING MODULES FOR CONTRACTORS

Module-3 CONSTRUCTION MEASUREMENT AND BASIC CALCULATIONS





Ministry of Rural Development

RURAL ROAD MAINTENANCE TRAINING MODULES FOR CONTRACTORS

Module-3

Construction Measurement and Basic Calculations



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:

- Measurement units
- Calculations

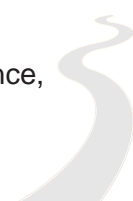
Learning Objective:

At the end of this Module you are expected:

- To be able to use correct measurement units
- To be able to calculate areas
- To be able to calculate volumes
- To be able to calculate slopes and gradients

Acknowledgement

The following publications were also used as reference materials:

- A Practitioner's Guide to Rural Roads Improvement and Maintenance, International Labour Organization and Government of Ghana, 2014
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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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JS (RC) & DG, NRRDA
Ministry of Rural Development
Government of India

October, 2015



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: CONSTRUCTION MEASUREMENT AND BASIC CALCULATIONS

Module 4: PLANNING AND WORK ORGANISATION

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: COSTING AND TENDERING

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.

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Construction Measurement and Basic Calculations

3.1 LENGTHS

Relationship between units of lengths

	mm	cm	m	km
1 mm	1	0.1	0.001	0.000001
1 cm	10	1	0.01	0.00001
1 m	1,000	100	1	0.001
1 km	1,000,000	100,000	1,000	1


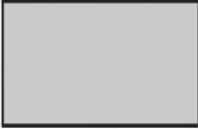
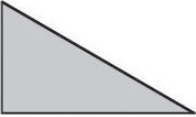
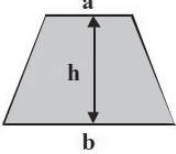
3.2 AREAS

Relationship between units of areas

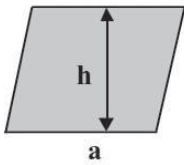
	mm ²	cm ²	m ²	hectare	km ²
1 mm ²	1	0.01	0.000001		
1 cm ²	100	1	0.0001		
1 m ²	1000000	10000	1	0.0001	0.000001
1 hectare			10,000	1	0.01
1 km ²			1,000,000		1

When working out areas, make sure all the measurements are of the same unit.

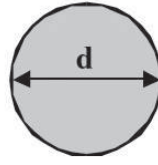
Calculation of area for different shapes

 <p>a</p> <p>a</p>	square: $a \times a$	 <p>a</p> <p>b</p>	rectangle: $a \times b$
 <p>h</p> <p>a</p>	triangle: $\frac{a \times h}{2}$	 <p>a</p> <p>h</p> <p>b</p>	trapezoid: $\frac{a + b}{2} \times h$





rhombus: $a \times h$



circle:

$$\text{area} = \frac{d^2 \times 3.142}{4}$$

$$\text{circumference} = d^2 \times 3.142$$

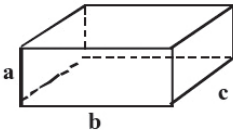
3.3 VOLUME

Relationship between units of volumes

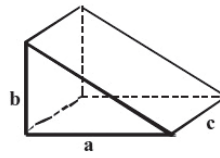
	cm ³	litre	m ³
1 cm ³	1	0.001	0.000001
1 m ³	1,000,000	1,000	1

When working out volumes, make sure all the measurements are of the same unit.

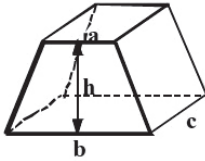
Calculation of volumes of different shapes



rectangular prism:
 $a \times b \times c = v$



triangular prism:
 $\frac{a \times b}{2} \times c = v$

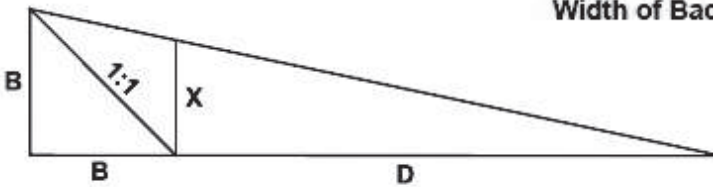


quadrilateral prism:
 $\frac{a + b}{2} \times h \times c = v$



cylinder: $\text{area} \times h$
 $\frac{d^2 \times 3.142}{4} \times h = v$

Examples:



Width of Backslope B:

$$\frac{B}{B+D} = \frac{X}{D}$$

↓

$$B = \frac{D \cdot X}{D - X}$$



Area of Cross Section:

$$\begin{aligned} A &= A_1 - A_2 \\ &= \frac{(B+D) \cdot B}{2} - \frac{B \cdot B}{2} \end{aligned}$$

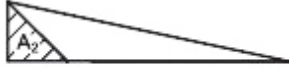


$$= \frac{(B+D) \cdot B}{2} - \frac{B \cdot B}{2}$$

$$= \frac{D}{2} \cdot B$$

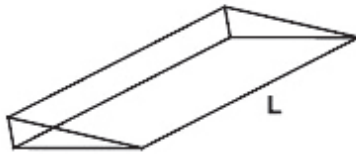
$$= \frac{D}{2} \cdot \frac{D \cdot X}{D-X}$$

$$= \frac{D^2 \cdot X}{2(D-X)}$$



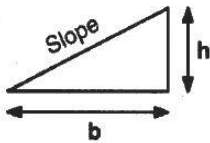
Volume to be excavated over a road section L is then:

$$V = \frac{D^2 \cdot X}{2(D-X)} \cdot L$$



3.4 SLOPES AND GRADIENTS

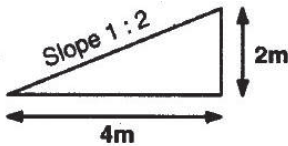
In road works, slopes are expressed in ratio and gradients in percentages.



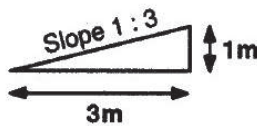
h = vertical distance
b = base = horizontal distance

$$\text{Slope} = \frac{\text{vertical distance}}{\text{horizontal distance}}$$

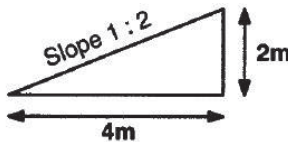
Examples:



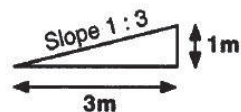
$$\text{Slope} = \frac{\text{vertical distance}}{\text{horizontal distance}} = \frac{2}{4} = \frac{1}{2} = 1:2$$



$$\text{Slope} = \frac{\text{vertical distance}}{\text{horizontal distance}} = \frac{1}{3} = 1:3$$



$$\text{Gradient} = \frac{\text{vertical distance} \times 100\%}{\text{horizontal distance}} = \frac{2 \times 100\%}{4} = 50\%$$



$$\text{Gradient} = \frac{\text{vertical distance} \times 100\%}{\text{horizontal distance}} = \frac{1 \times 100\%}{3} = 33.33\%\dots$$





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