



Manual Rehabilitation Labour-Based Technology for Rural Road Works



Don Bosco Foundation
Training Center in Comoro

LBT Training Manual

Contents

Module	Introduction
Module A	Mensuration
Module B	Soils
Module C	Labour-based Technology
Module D	Road Terminology
Module E	Work Organisation
Module F	Setting Out
Module G	Earth Work
Module H	Drainage
Module I	Graveling
Module J	Surface Options
Module K	Concrete & Stone Masonry
Module L	Drainage Structures
Module M	Cross Cutting Issues
Module N	Reports & Administrative Forms
Module O	Work Sheets
Module P	Index & References

LBT Training Manual

Introduction

Copyright © ILO & Don Bosco Timor-Leste, First published 2012

Short excerpts from may be reproduced without authorization, on condition that the source is indicated. For rights of reproduction or translation, application should be made to ILO & Don Bosco in Timor-Leste. Organisations and institutions may make copies in accordance with the license issued to them for this purpose

Manual, Labour-based Technology for Rural Road Rehabilitation

Timor-Leste, ILO & Don Bosco 2012

ISBN: 978-92-2-129453-5

Visit our website: www.donbosco.tl

Table of Contents, Introduction

Contents of the Manual	4
Foreword.....	5
Acknowledgement	6
1 Introduction.....	7
1.1 The road network in Timor-Leste.....	7
1.2 The Importance of Good Access	7
1.3 Strategy	8
1.4 Project Management.....	9
2 Technology Choice.....	9
3 Training.....	10
3.1 Overall training Programme.....	11
4 This manual.....	12

Contents of the Manual

Module	Introduction, 12p
Module A	Mensuration, 10p
Module B	Soils, 7p
Module C	Labour-Based Technology, 16p
Module D	Road terminology, 7p
Module E	Work organisation, 21p
Module F	Setting out, 21p
Module G	Earth works, 17p
Module H	Drainage, 11p
Module I	Graveling, 16p
Module J	Surface options, 29p
Module K	Concrete & stone masonry, 17p
Module L	Drainage structures, 35p
Module M	Cross cutting issues, 19p
Module N	Reports and site administrative forms, 18p
Module O	Work Sheets, 51p
Module P	Index and References, 5p

Foreword

Recognizing the enormous twin challenges of the need for infrastructure improvement and the need for job creation and, the Government of Timor-Leste is implementing a series of rural infrastructure works programmes using labour-based work methods as a means of building and maintaining quality infrastructure and at the same time providing jobs to unemployed people in the country.

Another government priority is to support the development of the domestic private sector contractors to ensure their capacity to produce quality works and enable them to contribute meaningfully to the development of the country. The new Secretariat of State for Support and Promotion of Private Sector (SEAPRI) is the key government institution in this regard.

A number of programmes have successfully demonstrated the viability of labour-based (equipment supported) work methods in Timor-Leste in order to provide good quality outputs and short-term employment opportunities for unskilled and semi-skilled workers in the rural communities. These programmes have contributed to employment generation, poverty reduction, economic growth and peace building and increased local capacity to plan and manage such programmes.

The continued effort to develop national and local capacities, both in public and private sector, to plan and implement routine road maintenance using labour-based methods is critical, and outsourcing implementation of works to local contractors and community groups increases the impact of rural infrastructure investments on poverty reduction, employment creation, crisis prevention and community-level social stability.

Don Bosco Training Centre is now providing technical training and national certification to local contractors in both rural road rehabilitation and maintenance approaches using labour based technology. The development and implementation of this training is supported by the International Labour Organization through the Enhancing Rural Access project (ERA), which is fully funded by the European Union.

The increased capacity amongst contractors and contract managers will be needed for planned investments in the rural roads sector, particularly through the Ministry of Public Works, and SEAPRI will continue to promote and support the involvement of certified private sector contractors in infrastructure works.

Acknowledgement

The purpose of this training manual is to provide technical management staff and contractors with appropriate guidelines for the effective management of rural road rehabilitation works using Labour-Based Technology.

This Training Manual is based on the Labour-Based Technical Manual developed for Timor-Leste, which in turn was based on the Rural Road Management Manual originally prepared for the Ministry of Rural Development in Cambodia. The Timor-Leste Labour-Based Manual, first prepared under the TIM Works Project to reflect the local conditions in Timor-Leste has been reviewed and revised, based on experience and other relevant literature through the ERA Project for Don Bosco Training Centre to suit training of small scale contractors.

It is hoped that this manual in combination with adequate training will provide sufficient guidance to technical staff carrying out rural works on rural roads in Timor-Leste.

Father Antonio Transfiguração Pinto
Director Don Bosco Foundation, 2012

1 Introduction

1.1 The road network in Timor-Leste

The road network in Timor-Leste is estimated at 6,036 km in length, including 716 km of roads in Dili and several smaller regional towns. About 1,426 km of the network links Dili to the twelve district centres, and forms the national network. A length of 2,220 km provides essential connectivity for the nation, and includes national roads and 869 km of district road, providing links to large administrative centres. The remaining 3,025 km are rural access and feeder roads.

About 80% of the core road network is paved with approximately 317 bridges. While the road network is extensive, road standards are generally poor. Pavements are generally narrow (3.5 to 5.5 meters) and vertical and horizontal alignments commonly limit sight distance, restricting travel speeds, reducing the ability to overtake, and increasing the risk of accidents. Inadequate drainage exacerbates road damage. The quality of the road surface for a little over half of the core network is poor or very poor.

The overall condition of roads at district and rural level is very poor. A comprehensive inventory and classification exercise for rural roads is underway as well as the development of a rural roads policy and appropriate design standards for rural roads.

While rural feeder roads are largely unsealed, the majority are little more than tracks, and as such, are largely unmaintainable in their present state. The difficulty and expense of maintaining them will be significant given the adverse topology and climate seen in Timor-Leste.

For the district and rural road network there is currently no systematic routine maintenance taking place, however, the importance of routine maintenance is recognised by the Government and the Roads for Development Programme (R4D) under the Ministry of Public Works now attempts to introduce a nationwide system for routine maintenance.

1.2 The Importance of Good Access

The majority of the population of Timor-Leste lives in the rural areas. Their primary means of transport is through the use of an access road, linking into district roads before connecting to the national roads.

Results of Poor Access

- Farmers are reluctant to grow marketable surplus crops because it cannot be sold or due to the difficulty and expense of transport significantly reduces the returns to labour;
- Agricultural productivity is low and there is a lack of innovation because extension information and inputs do not reach the farmers;
- School enrolment is low and absenteeism is high (among both teachers as well as children);
- Standards of health care are low because clinics are hard to reach and health workers cannot travel easily;
- Women's working days are long and arduous, largely owing to the time and effort required to reach water, fuel and other sources.

Isolation is a fundamental characteristic of poverty and good access provides the way to reduce that isolation.

Currently, a large portion of rural communities do not have this access facility and despite the fact that several rural development programmes are involved in building local roads, the combined effect of an insufficient network and the lack of maintenance keeps the rural population isolated from the rest of society.

Lack of maintenance, therefore, is a major issue in financial terms given the loss of investment - in addition to the effects of reduced service levels. Of equal importance, in the case of rural roads, is the resulting lack of access and the implications for rural people. If rural roads are not maintained they finally deteriorate to levels making them impassable during long periods.

Lack of access has its effect at the most basic level of living. If there is poor access to health services, people will remain unhealthy, children will die, and any epidemic is likely to have catastrophic results. If there is poor access to clean water, again health will suffer. If there is poor access to basic information the household will be unaware of ideas and technology that might help lift their standard of living. And if there is poor access to education, children will in the future share the limitations confronting their parents today. In addition, lack of access to markets ensures that whatever potential that exists for marketing crops and participating in other economic activities are limited. In summary, the lack of maintenance is often a major impediment to the achievement of a country's poverty reduction goals.

All year round access requires a continuous road maintenance regime. When applying labour-based work methods its employment generation potential should not be under-estimated. These employment opportunities, whether they are temporary or on a continuous basis, provide a significant cash injection into rural communities where subsistence farming constitute the mainstay of the economy. Cash for work schemes in Timor Leste have clearly demonstrated that road maintenance can generate much needed jobs and income for people living in rural areas. By establishing a permanent system for maintenance of the road network, employment opportunities can be sustained while at the same time maintaining the investments made in the country's road network.

Any development plan which has a poverty reduction objective needs to have within it the appreciation of the fundamental value of effective rural road maintenance for the achievement of those objectives. Rural road maintenance is not therefore just a financial and economic issue. It is also a humanitarian priority.

1.3 Strategy

Rural road rehabilitation can be effectively organised relying on in-country resources and minimising the use of imported goods and services, thereby boosting local economies and increasing employment opportunities. Casual labour combined with the

use of hand tools and light equipment is thus utilised to carry out all road works operations providing a functional road network which responds to the dire demand for access to and within the rural areas.

Labour-based technology in rural infrastructure works optimises the use of productive labour and complements the use of labour with essential equipment necessary to meet the specified technical and engineering standards. Labour-based methods result in at least 5 times the number of jobs being directly created in rural roads construction and maintenance, as would be the case using conventional equipment based technology. Labour-based technology is therefore socio-economically ideal for use in Timor-Leste where there is relatively low cost of labour and high levels of available unemployed or under-employed labour.

1.4 Project Management

Whilst roads principally are the domain of the Ministry of Public Works, Don Bosco is through the ERA Project providing training to small scale contractors and communities in routine maintenance and as part of this training also offering trial maintenance contracts. The objective is to train a pool of local contractors who can participate in works procured by the government, mainly through the Ministry of Public Works. The management arrangements in these guidelines refer to ERA Project as the client. However, ERA can simply be replaced with MPW and the ERA Maintenance Engineer with the MPW Supervisor whilst keeping the same management arrangements.

The ERA Maintenance Engineer identifies the roads to be included for rehabilitation and maintenance (as a principle all recently rehabilitated roads and in coordination with Local Authorities and Public Works Supervisors) and carries out a detailed road condition survey to determine the amount of work (BoQ) and prepares the overall work plan.

The ERA Project prepares the contract based on those estimates and issue a contract to a trained contractor, either through direct award or through a bidding process.

2 Technology Choice

Road rehabilitation and maintenance offers considerable scope for increasing efficiency by adopting work methods and approaches relying to a large extent on locally available resources. This not only includes the introduction of labour-based works technology but also by involving local construction firms and communities in works implementation.

The use of heavy equipment increases the complexity of work operations with the result that work progress becomes more reliant on the steady supply of spare parts and repair

services. Furthermore, equipment requires skilled operators, skilled mechanics and proper workshop facilities. If any of these items are not available, the equipment ends up standing idle and road maintenance is not carried out. It is not uncommon

that work progress is disrupted due to lack of simple spare parts or repair services. Moreover, due to the high initial investments, small-scale local contractors are thereby barred from carrying out works contracts which could be carried out using alternative work methods.

By contrast, labour is practically always readily available and can be employed at a low cost. In addition, labour-based techniques are very well suited to a wide range of rural road works activities, particularly when the work force is properly managed, relying on an output-based payment system. However, labour-based approaches demand proper planning and skilled supervision.

Often, a combined use of labour and machines provide the most appropriate solution. Certain tasks can be carried out more effectively using machines, while others are best carried out relying on manual labour. The most appropriate technology depends on the nature of the work and the availability of labour and equipment in the area.

The choice between equipment and labour-based work methods affects the basic organisation of road rehabilitation and maintenance. Relying to a high degree on the use of heavy equipment entails the involvement of larger contractors, whereas labour-based work methods favour more decentralised solutions based on the use of locally available resources.

In most cases, the choice between labour and machines is not an either/or situation - it is possible to find cost-effective solutions combining the two approaches. Moreover, past experience has shown that an innovative use of intermediate equipment can be cost-effective for excavation, compaction and hauling, provided that locally available skills and materials are drawn upon in an imaginative way.

When applying labour-based work methods its employment generation potential should not be under-estimated. These employment opportunities, whether they are temporary or on a continuous basis, provide a significant cash injection into rural communities where subsistence farming constitute the mainstay of the economy. Cash for work schemes in Timor Leste have clearly demonstrated that road maintenance can generate much needed jobs and income for people living in rural areas. By establishing a permanent system for maintenance of the road network, employment opportunities can be sustained while at the same time maintaining the investments made in the country's road network.

3 Training

One of the cornerstones of the ERA Project is to ensure sustainability of its capacity building activities. The Project will therefore work with Don Bosco Foundation (Training Centre in Comoro) and IADE (Instituto de Apoio ao Desenvolvimento Empresarial) to develop their capacities to deliver comprehensive training courses for small scale domestic contractors and their staff in the planning, tendering, implementation and management of labour-based rural road rehabilitation and maintenance works.

The ERA Project will provide training to local contractors and their engineers and road supervisors. As part of the training for the contractors and their staff, trial contracts will be issued to those contractors who have successfully completed the classroom training and practical site application. The training under the ERA Project includes technical training for the labour-based road construction and maintenance approach, and contract management and business management training. The training has thus been divided into three distinct units:

- ✚ Technical training in Labour-based Technology (LBT). Labour-based, equipment supported methods for rural road rehabilitation and maintenance training is provided to road supervisors and engineers of the selected companies.
- ✚ Contract management training is provided to the directors and engineers of the selected companies.
- ✚ Business management training is provided to directors of the selected companies.

The technical training for the contractors in rural road rehabilitation is provided by Don Bosco Training Centre as the *National Certificate in Labour-Based Technology for Rural Road Construction*, and the training in contracts management and business management is provided by IADE as the *National Certificate in Managing Small Bids and Contracts*.

Since the contractors who participate in the ERA technical training will be offered trial contract they need specific knowledge of ERA tendering procedures and unit rate analysis for rural road works. Don Bosco therefore provides tailor made training on FIDIC Short Form of Contract and Unit Rate analysis for engineers and directors from companies that will participate in ERA contracts.

3.1 Overall training Programme

The overall training programme offered to domestic contractors to manage labour-based rural road works include technical and management training for contractor's staff including, the company's director, the company engineer and supervisors. Because of their different backgrounds and their different roles in the construction project they require different types of training. Whilst the supervisors need more thorough training focusing on technical aspects the engineer and director also need management training.

The training is therefore tailored to the needs of each category of staff. The bar chart below shows proposed type and duration of training for the contractor's different staff.

Staff/type of training					Weeks										
		Advertisement			1	2	3	4	5	6	7	8			
Supervisor (3)	Technical training	Don Bosco													
	Practical training														
Engineer (1)	Technical training														
	Unit rate calculations														
	Practical training														
Director (1)	Unit rate calculations														
	Contracts management	IADE													
	Business management														
															Tender

4 This manual

The ***Training Manual for Labour-Based Technology*** has been prepared for training purpose of the ERA project. This Training Manual is developed for the LBT technical training for site supervisory staff, engineers and supervisors with aims to equip the engineers and supervisors with sufficient knowledge and appropriate techniques to plan, implementing and monitoring the Labour-based road construction and rehabilitation works. The Manual consists of guidelines for managing labour-based rural road works accompanied by examples, and including job work sheets with detailed and practical instructions how to carry out activities, including important quality checks.

This manual:

- ✚ describes in detail the management procedures for road rehabilitation works, including labour-based work organisation, planning, sequencing of works and balancing of work gangs.
- ✚ provides guidelines on planning of works, work norms, organisation and how works are effectively measured and controlled, and describe the tools and equipment used in Labour-Based rural road works
- ✚ gives information on how to set out road alignments and cross sections using simple methods. Describes the various construction activities including earth works and pavements and structures
- ✚ discusses cross cutting issue and provides a reference on contracting arrangements.

LBT Training Manual

Module A

Mensuration

Table of Contents, Module A Mensuration

A	Mensuration	3
A-1	Length.....	3
A-2	Area	4
A-3	Volume	6
A-4	Weight and capacity.....	6
A-5	Slope	8
A-6	Pressure.....	9
A-6	Unit conversation	10

A Mensuration

In road construction works technical personnel in the field are confronted on a daily basis with the situation where a basic knowledge of mathematics becomes necessary. These situations include:

- ✚ setting out of alignments;
- ✚ detailed setting out of task work;
- ✚ calculation of areas and volumes of earth works;
- ✚ calculation of masonry and concrete work;
- ✚ calculation of equipment performance rates;
- ✚ estimation of productivity rates for labour, etc.

Worldwide the metric system is the universal system of measurements (System International = SI) with standard units for length, weight, time, temperature, etc. However, for certain jobs, like plumbing, the imperial system is still in use in some parts of the world. In fact, in many places certain construction materials are sold using the Imperial or US system for measurements, e.g. timber and reinforcement bars are sold by the foot.

A-1 Length

Definition = the standard unit for length is the **metre** (m). For shorter lengths, centimetre (1m = 100cm) is used which is again subdivided into millimetres (1cm = 10mm).

For longer distances however, kilometre (1000m = 1km) is used.

For construction work the most common and practical units are metre (m) and centimetre (cm)

A good construction drawing does not mix units but maintains one standard unit for all measurements. The unit used should always be indicated on the drawing.

Conversion:

	mm	cm	m	km
1 mm	1	0.1	0.001	0.000001
1 cm	10	1	0.01	0.0001
1 m	1,000	100	1	0.001
1 km	1,000,000	10,000	1,000	1

A-2 Area

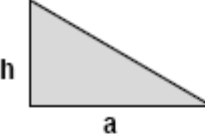
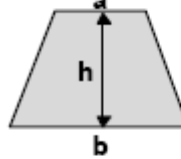
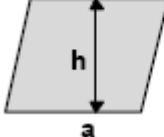
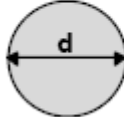
Definition = 1m^2 (square metre) is the area of a square having sides whose length is 1m. Consequently every unit of length can be converted into an area if it is multiplied by itself.

To convert the area to one unit higher multiply it by 100 and from a higher to a lower unit divides it by 100 as shown in the table below.

Relationship between the various units or areas:

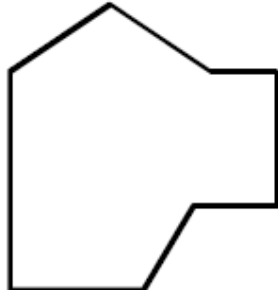
	mm^2	cm^2	m^2	km^2
1 mm^2	1	0.01	0.0000001	
1 cm^2	100	1	0.0001	
1 m^2	1,000,000	10,000	1	0.000001
1 km^2			1,000,000	1

Calculation for areas:

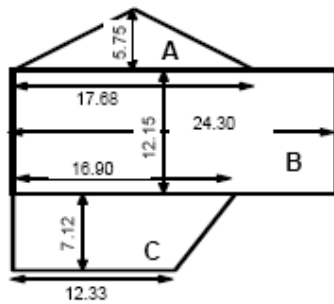
 square: $a \times a$	 rectangle: $a \times b$
 triangle: $\frac{a \times h}{2}$	 trapezoid: $\frac{a + b}{2} \times h$
 rhombus: $a \times h$	 circle: area = $\frac{d^2 \times \pi}{4}$ circumference = $d \times \pi$

Example

You are asked by the Engineer to prepare an estimate for the surfacing of the borrow pit where the house is situated and where some of the boulders and big trees are surrounded. Before you can calculate the area you have to prepare a sketch with all the measurements. Your sketch of the place looks like this:



Before you start to take the measurements you have to subdivide the place into areas which you can easily calculate. (The typical sample areas are shown in the table above)



Once you have done the sub-division you can then take the measurements. For a place of this size we suggest to use "metre" as your unit of measurement. Your sketch now looks like this. It is now relatively easy to calculate the individual areas and add them up to the total area of the communal place

Calculations:

$$\text{Area Triangle A: } a \times b / 2 = 17.68\text{m} \times 5.75\text{m} / 2 = 50.83 \text{ m}^2$$

$$\text{Area Rectangle B: } a \times b = 24.30\text{m} \times 12.15\text{m} = 295.25 \text{ m}^2$$

$$\text{Area Trapezoid C: } (a + b) / 2 \times h = (16.90\text{m} + 12.33\text{m}) / 2 \times 7.12\text{m} = 104.06 \text{ m}^2$$

$$\text{TOTAL Area of the borrow pit} = 450.14 \text{ m}^2$$

A-3 Volume

Definition = 1m^3 is the volume of a cube with a length of side of 1m. Volumes are calculated by multiplying a base area(m^2) with a third dimension.

Therefore:

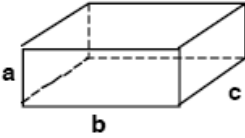
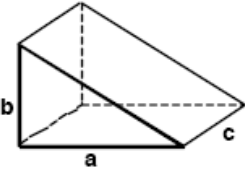
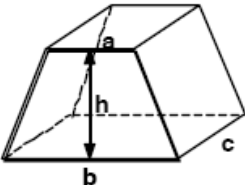
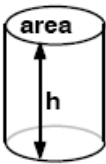
$\text{mm}^2 \times \text{mm} = \text{mm}^3$	$\text{cm}^2 \times \text{cm} = \text{cm}^3$	$\text{m}^2 \times \text{m} = \text{m}^3$	$\text{km}^2 \times \text{km} = \text{km}^3$
--	--	---	--

If you have to change a volume from one unit to the next lower or higher one, you have to multiply or divide the quantity by 1,000 (one thousand) respectively.

Relationship between the various units of volume:

	mm^3	cm^3	dm^3 (1 litre)	m^3
1 mm^3	1			
1 cm^3		1	0.001	0.000001
1 dm^3 (litre)		1,000	1	0,001
1 m^3		1,000,000	1,000	1

Calculation of volumes:

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

A-4 Weight and capacity

Weight

Definition = 1 kilogram (kg) is the weight of one cubic decimeter (dm^3) or one litre of water with a temperature of 4°C . Other units are: gram (g) and tone (t).

Therefore:

$1\text{kg} = 1,000\text{g}$	$1\text{t} = 1,000\text{kg}$	$1\text{kg} = 0.001\text{t}$	$1\text{g} = 0.001\text{kg}$
------------------------------	------------------------------	------------------------------	------------------------------

Note: the most important units for construction works are = kg and tonne

Relationship between the various units of volume:

	gram	kilogram	tonne
1g	1	0.001	0.000001
1kg	1,000	1	0.001
1t	1,000,000	1,000	1

Capacity

Definition = 1 litre of water is the volume of water contained in one cubic decimetre (dm^3 = a cube with 10cm sides) at 4°C.

Therefore:

$1\text{dm}^3 = 1 \text{ litre}$	$1\text{m}^3 = 1,000 \text{ litre}$	$1 \text{ litre} = 0.001\text{m}^3$
--	---	---

Relationship between volume, capacity and weight:

$1\text{dm}^3 = 1 \text{ litre} = 1\text{kg}$	$1\text{m}^3 = 1,000 \text{ litre} = 1\text{t}$	$1 \text{ litre} - 0.001\text{m}^3 = 0.001\text{t}$
---	---	---

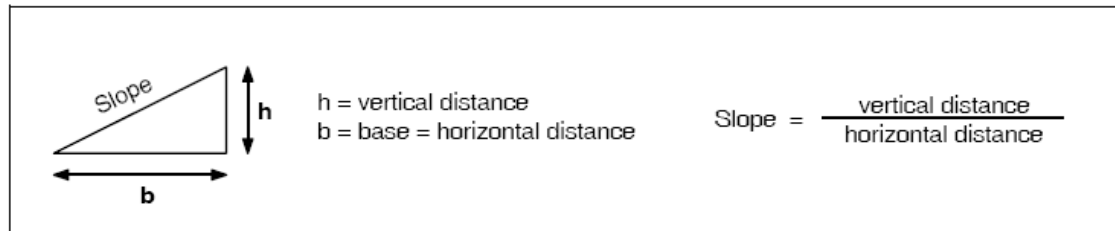
Density

Definition = weight in kg per m^3 volume in normal processed condition of the material (density).

	kg/m^3		kg/m^3
Steel and Iron	7,800	Stone for masonry (dense)	2,500-3,000
Aluminium	2,700	Stone for masonry (porous)	2,200-2,500
Copper	8,900	Building sand (natural moisture)	1,900-2,100
Lead	11,340	Building sand (dry)	1,800-2,000
Wood	400-800	Gravel (clean, without fines)	1,500-1,800
Hardwood	700-1,000	Cohesive soil	1,800-2,000
Asphalt	1,600-2,000	Heavy clay	1,800-2,000
Bitumen	1,100	Cement or lime mortar	1,900-2,100
		Cement (loose)	1,200-1,400
		Lime (loose)	900-1,300
Cement stone wall (with mortar)	1,800-2,000		
Lime stone wall (with mortar)	1,600-2,000	Concrete with reinforcement	2,300-2,500
Brick wall (with mortar)	1,300-1,500		
Masonry wall (with mortar)	2,000-2,200	Water	1,000

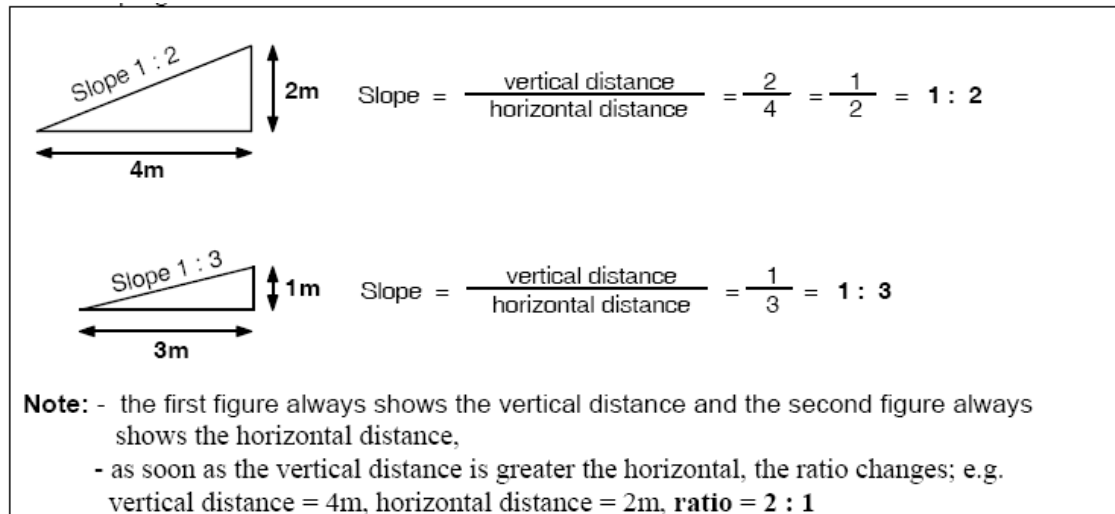
A-5 Slope

Definition = the slope shows the steepness of an ascent or descent.



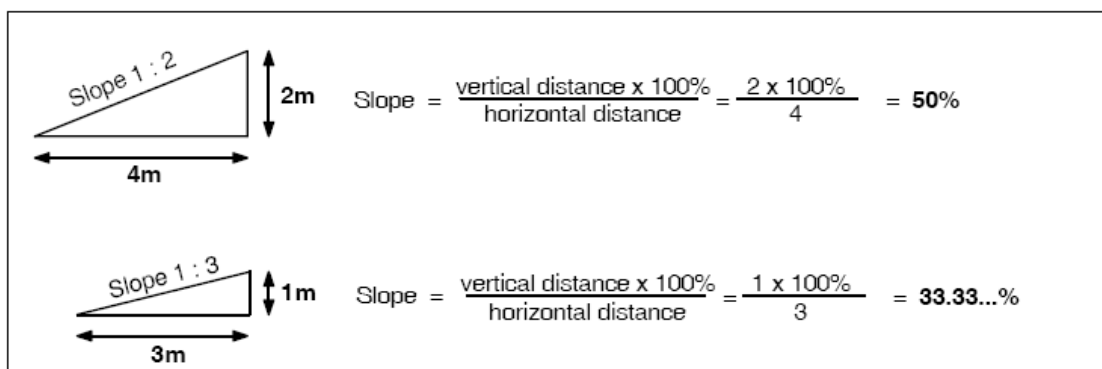
Slopes can be expressed as a **ratio** or in **percentage**.

Slope given as a ratio:



Slope given in percentage (%):

Any fraction (ratio) can be expressed in % by dividing the numerator by the denominator and multiplying the result by 100%.



Formulas:

Slope = height / base

height = base x slope

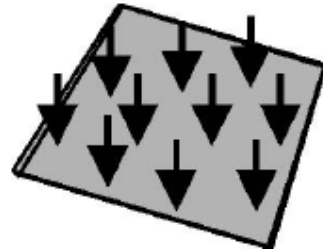
base = height / slope

A-6 Pressure

Definition = The exerted one unit area on the surface on which it is in contact. The standard unit is Newton (1kg = 10 Newton) per square metre (Pascals) in SI units.

An alternative unit is the bar which is 10^5N/m^2

The mass density of water is 10^3 kg/m^3



Pressure:

P = Force (F) / Area (A); Force is measured in Newton (N) and Area is measured in m^2 and cm^2

Remember!

Do not mix the measurement systems and units. Before you make any calculations you have to make sure that you use one system and one unit only

-  **Length:** for construction work the most common and practical units are metres and centimetres.
-  **Area:** when working out areas always make sure that all the units are the same! For practical reasons use metres.
-  **Volume:** the most important units for construction works are cm^3 and m^3 . For practical reasons use metres.
-  **Weight:** the most important units for constructions works are = kilograms and tonnes.
-  **Slopes:** can be expressed as a ratio or in percentage.
-  **Pressure:** the standard unit is Newton per square metre ($\text{N/m}^2 = \text{Pascal}$)

A-6 Unit conversation

Unit conversation table						
Unit system	Metric		Imperial & US			
Length	Metre (m)	Kilometre (km)	Inch (in)	Foot (ft)	Yard	Mile
	1	0.001	39.3701	3.28084	1.09361	0.00062
	1,000	1	39370.1	3,280.84	1,093.61	0.62137
	0.0254	0.00003	1	0.08333	0.02778	0.00002
	0.3048	0.00030	12	1	0.33333	0.00019
	0.9144	0.00091	36	3	1	0.00057
	1,609.34	1.60934	63,360	5,280	1,760	1
Unit system	Metric				Imperial & US	
Area	Square metre (m ²)	Are (a)	Hectare (Ha)	Square kilometre (km ²)	Square yard	Acre
	1	0.01	0.0001	0.000001	1.19599	0.00025
	100	1	0.01	0.0001	119.599	0.02471
	10,000	100	1	0.01	11,960	2.47105
	1,000,000	10,000	100	1	1,196,000	247.105
	0.83613	0.00836	0.00004		1	0.00021
	4,046.86	40.4686	0.40469	0.00405	4,840	1
Unit system	Metric		Imperial & US			
Volume	Cubic metre (m ³)	Litre (lt.)	U.S. Gallon	Cubic inch	Cubic feet	Imperial Gallon
	1	1,000	264.171	6,1023.7	35.3147	219.978
	0.001	1	0.26418	61.0255	0.03532	0.21998
	0.00379	3.78532	1	231.001	0.13368	0.83270
	0.00002	0.01639	0.00433	1	0.00058	0.00360
	0.02832	28.316	7.48048	1,728	1	6.22883
	0.00455	4.54596	1.20095	277.42	0.16054	1
Unit system	Metric			Imperial & US		
Weight	Gram (g)	Kilogram (kg)	Ton (t)	Carat	Ounce (oz)	Pound (lb)
	1	0.001		5	0.03527	0.00220
	1,000	1	0.001	5,000	35.274	2.20462
	1,000,000	1,000	1	5,000,000	35,274	2,204.62
	0.2	0.0002		1	0.00705	0.00044
	28.3495	0.02835	0.00003	141.748	1	0.06250
	453.592	0.4359	0.00045	2,267.95	16	1

LBT Training Manual

Module B

Soils

Table of Contents, Module B Soils

B	Soil	3
B-1	Introduction.....	3
B-2	Terminology and definitions	3
B-3	Soil characteristics.....	5
B-4	Summary soil classification	5
B-5	Identification of soils	6
B-6	Characteristics of soil for road work	6

B Soil

B-1 Introduction

The soil forms the primary building material especially on road projects. It is therefore important for contractors to know how to recognize which soils are suitable for road works and which are not. Contract specifications often describe the required quality of soils, which contractors must be capable of interpreting in specialist terminology. Often simple field tests are necessary to make the required choice of suitable material.

B-2 Terminology and definitions

According to particle (grain) size; the nature of the soil depends largely on the sizes of particles forming the solid part of the soil and are the basis for the identification of different soils.	
<i>Gravel</i>	Consists of 2-60 mm stones (the term gravel is also used in road terminology for a mixture of stones, sand and clay for surface layers)
<i>Sand</i>	Grains of size 0.06-2 mm, coarse to fine gritty soil, firm when dump
<i>Silt</i>	Fine grain soil of size 0.002-0.06 mm, non plastic, when dry = fine soft powdery silt and does not stain hands when wet
<i>Clay</i>	Very fine soil of size 0-0.002 mm, plastic. When dry = hard lumps cracked surface and stains hands when wet
<i>Organic soil</i>	The soil contains remnants of plants, roots, etc and has a distinct smell, dark in colour
According to soil fractions: Natural soil usually consists of a mixture of all or some of the particle sizes, silt, clay, sand and gravel	
<i>Coarse grain soils</i>	The soil consist mainly of sand and gravel, with little or no silt or clay
<i>Fine grain soils</i>	Mainly silt and clay
<i>Cohesive</i>	The soil sticks together, mainly clay
<i>Non cohesive</i>	The soil does not stick together, mainly sand and gravel

<i>Well graded</i>	A wide range of particle sizes which are well distributed (note: a mixture of particle sizes means that the soil will be easier to compact)
<i>Poorly graded</i>	Not all particle sizes are present in the soil, too much of some sizes and too little of others
<i>Uniformly graded</i>	Soil with a limited range of sizes, mainly concentrated in one size category
<i>Proportions of soil fractions</i>	E.g. 10% gravel, 20% sand, 50% silt and 20% clay
According to soil conditions: Indicates the state of the soil	
<i>Plasticity</i>	The degree to which the soil can be moulded (clay is very plastic)
<i>Moulding</i>	Forming soils in certain shapes (e.g. threads)
<i>Stability</i>	A stable soil, is not easily deformed
<i>Bearing Capacity</i>	The ability (strength) of the soil to carry surface loads (measured by the weight that can be loaded on to a specified area without penetration – or the amount of penetration under a certain load on a specified area)
<i>Density</i>	In a dense soil of particles are close together (or well compacted)
<i>Optimum Moisture Content (OMC)</i>	The water content which gives the best effect of soil compaction
<i>compaction</i>	The process which packs the particles close together (by pressure, tamping or vibration) and consequently increasing the density and bearing capacity
<i>Permeability</i>	The degree to which water can penetrate a particular soil

B-3 Soil characteristics

The behavior of soils depends upon two basic factors:

- (i) Composition, proportion of soil fractions
- (ii) Condition of the soil, water and air content

<i>Fine grain soil</i>	Silt and clay are strongly affected by the amount of the water present (moisture content). With increasing moisture content the silt and clay will: - first become plastic = can be moulded - then become liquid = begins to flow like water
<i>Coarse grain soil</i>	Sand and gravel area affected to some extent by increased moisture content, but not extensively.
<i>Combination soil</i>	Soils by nature are a combination of coarse and fine grain soils. both the moisture content and the particle distribution affect their behaviour.

B-4 Summary soil classification

<i>Division</i>	<i>Types</i>	<i>Grain sizes (mm)</i>		<i>Sub- groups</i>	<i>Characteristics</i>
		<i>Min.</i>	<i>Max.</i>		
	Stones	60		-	-
Coarse grained soils, non cohesive	Gravel	2	60	Gravel with few fines	The amount of fines does not exceed 12% of the total weight. Gravel can be well graded or poorly graded
				Gravel with many fines	The amount of fines exceeds 12% of the total weight.
	Sand	0.02	2	Sand with few fines	The amount of fines does not exceed 12% of the total weight. Sand can be well graded or poorly graded
				Sand with many fines	The amount of fines exceeds 12% of the total weight.
Fine grained	Slit	0.002	0.06	-	Gritty to touch, slight cohesion

soils, cohesive	Clay	-	0.002	-	Smooth and greasy to touch, high cohesion
Organic soils	-			-	Usually contains remnants of plants, roots, etc. and has a distinct smell, dark in colour.

B-5 Identification of soils

By means of visual inspection and simple field tests it is possible to identify any type of soil and classify it in one of the subgroups as described in section B4. (Laboratory tests are necessary if a detailed soli classification is required)

Suitability for road works: Gravel with few fines = good, Gravel with many fines = fair, Sand with many fines = fair, Sand with few fines = poor

Unsuitable for road works: Silt, Clay and Organic soil

B-6 Characteristics of soil for road work

Soil Types	Grading	Compressibility when compacted	Bearing capacity	Resistance to wear and tear	Suitability as road material
Gravel with few fines	well graded	almost none	excellent	good	excellent
	poorly graded	almost none	fair to good	Fair	good
Gravel with many fines	well and poorly graded	slight	fair to excellent	fair to good	fair
Sand with few fines	well graded	almost none	poor to fair	good	fair
	poorly graded	almost none	Poor	Poor	poor to fair
Sand with many fines	well and poorly graded	slight to medium	poor to fair	fair to good	poor to not suitable
Silt	-	medium	very poor	very poor	not suitable
Clay	-	high	very poor	Poor	not suitable
Organic	-	very high	very poor	very poor	not suitable

The ideal composition (grading) of gravel material is usually determined by the given standards of the client and is often also described in detail in the contract specifications. In the absence of norms a rule of thumb maybe applied as below:

 Fines	= 10% Clay and Silt (smaller than 0.06mm)
 Medium	= 40% Sand (0.06-2.0mm)
 Coarse	= 50% Stones (bigger than 2.0-37.5mm)

LBT Training Manual

Module C

Labour-Based Technology

Table of Contents, Module C Labour-Based Technology [LBT]

C	Labour-Based Technology [LBT]	3
C-1	Labour issues	3
C-2	Hand tools	6
C-3	Tools for setting out and quantity surveying	11
C-4	Quantities of hand tools and survey instruments for Labour-Based road works.....	15
C-5	Light equipment	16

C Labour-Based Technology [LBT]

Labour-based Technology (LBT) is defined as the construction technology which, while maintaining cost competitiveness and acceptable engineering quality standards, maximizes opportunity for employment.

This work method utilizes locally available resources, like skilled and unskilled labour, material and light equipment. Design, work preparation and contract documentation are usually specifically tailored for this approach.

Labour-based Technology refers to a methodology utilising labour and hand tools supported by light equipment.

-  using labour-based construction methods to provide employment opportunities to local unemployed people;
-  providing training or skills development to those locally employed workers;
-  building cost-effective and quality assets.

C-1 Labour issues

Good management of labourers by the Contractor's Site Supervisor is extremely important for achieving productivity targets. A well organised and happy workforce is usually a productive work force.

Local labour is the main resource in Labour-based Technology and normally labour is recruited from the villages along the road. As a rule of thumb, labourers should be able to walk to and from the work site each day. In some cases, however, there is a limited supply of labour along the road and labour from vicinity community may be recruited.

The Contractor is responsible for the work and management of the labour work force and is responsible for:

- providing clear and timely information to the community
- planning and organising the works
- ensuring good practices and safe working conditions at all times
- setting tasks and monitoring completion of tasks
- managing site discipline
- payment of wages in full and on time

The Contractor's Supervisor must look out for problems with workers and take appropriate steps to deal with such issues at an early stage.

Principles of recruitment

-  The recruitment and employment procedures that will be adopted have to be first discussed and agreed upon with the community when local labour is going to be employed.

- ✚ Conditions of employment have to be worked out before hand and agreed on with all parties concerned. This requires awareness of international labour laws and regulations.
- ✚ In principle, the people to benefit from project employment should be the people living within the project area. Skills workers like masons, carpenters, steel bender may be hired from elsewhere if they cannot be found in the project area.

Labour work camps and/or transportation of labour from outside to the work site should be avoided.

Incentive payment scheme

Task work system is the preferred method used for work implementation. This system gives the worker one day's wage for a defined volume of work. The worker is given a task to complete and he or she is free to leave the work site when the work has been approved. This is then counted as a full day's work in the muster payroll. Task work has several advantages over daily paid work:

- ✚ planning of the work is simple because the output per workday is known;
- ✚ a higher output than daily work is achieved because the workers know their task and value the extra free time they are getting;
- ✚ supervision is easier because each worker knows exactly what to do. The workers are eager to finish work early every day.

A correct set task should allow most workers to complete their daily task in about six hours. Some will be faster and some will be slower. The tasks rates should be reviewed regularly to ensure that they are fair.

Payment of workers should be arranged at a regular interval agreed with the community, usually monthly, and near the site location and the Payment should be made directly to the worker who performed the work.

Core Labour Standards

The construction sector must adhere to international labour standards. The following core labour standards are applied for the Labour-based road construction and maintenance projects

Equality

-  *Men and women should receive equal pay for work of equal value.*
-  *Persons should be given equality of opportunity and treatment in employment and occupation. There should be no discrimination against persons in their employment and occupation on the basis of their race, color, sex, religion, political opinion, national extraction or social origin, or on any other basis set out in national legislation.*

Freedom from forced labour

-  *Work or service should not be exacted from any person under the menace of penalty or under circumstances where the person has not offered himself or herself voluntarily.*
-  *Work or service should not be exacted from any person:*
 - ☐ *as a means of political coercion,*
 - ☐ *as a method of mobilizing and using labour for purposes of economic development,*
 - ☐ *as a means of labour discipline,*
 - ☐ *as a punishment for having participated in strikes,*
 - ☐ *as a means of racial origin,*
 - ☐ *social, national or religious discrimination.*

Minimum age

-  *No person under the age of 18 should be employed or work.*
-  *The contractor should keep a record of copies of ID's of those workers who look young, so that they can provide proof of the age in case of inspection.*

Minimum wages

-  *Minimum wages should be established for groups of wage earners where, in consultation with employers and the national authority finds it appropriate. Minimum wages, where they exist, should have the force of law and should not be subjected to abatement; failure to pay minimum wages should be subject to penal or other sanctions.*

Protection of wages

- ✚ *Wages should be paid in cash money. Where wages are paid partially as set by the condition of contract. Employers should not limit in any way the workers' freedom in using wages. Workers should be informed of any deduction made from wages. Wages should be paid regularly at or near the place of work.*

Safety and health:

- ✚ *All appropriate precautions shall be taken to ensure that all workplaces are safe and without risk of injury to the safety and health of workers. Workers shall have the right and the duty at any workplace to participate in ensuring safe working conditions to the extent of their control over the equipment and the methods of work and to express views on the working procedures adopted as they may affect safety and health.*

C-2 Hand tools

In labour-based road construction and rehabilitation, workers mostly use hand tools. It is important to know how to select and maintain the tools as they have a significant influence on the effectiveness of labour-based methods.

Different construction activities require different types of tools and equipment. The Engineer should know how to use the different tools since they have to instruct the workers, who might not have used some of these tools before.

Hand tools are the major instruments by which the energy of the workers is applied to carry out the activities involved in constructing a road.

Hand tools are used much more intensively on labour-based road construction and rehabilitation works than in agriculture. Many tools which are adequate for agriculture work are not strong enough for use on road construction sites and will quickly break if used intensively.

- ✚ if the workers discover that their tools are not very strong, they will tend to use them more gently, and less productively, to avoid breaking them.
- ✚ tools breakage on site cause interruptions to work, and reduce productivity, while the tools are repaired or replaced.

Providing workers with strong, durable tools helps to increase productivity

Efficient hand tools are well adapted to particular construction tasks, comfortable to use, and suit the physical characteristics of the workers. Soil excavation is the main activity of this tertiary road rehabilitation works. The most common tools used for carrying out the labour based road works are described below.

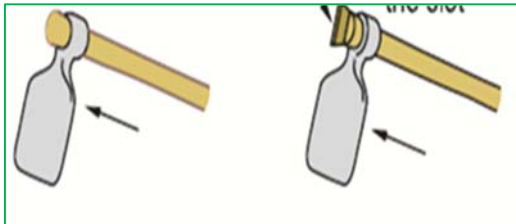
Activity	Required suitable tools
Soil excavation	• Crowbar • Pickaxe • Cutter mattock • Hoe • Shovel (for throwing the soil)

Hoe

The hoe is, in addition to be very useful in agriculture, also an important tool in labour-based road works. It can be used for excavation of soft soil. It consists of a blade and a handle.

The blade of the common hoe has a straight cutting edge. The eye can be round or oval, although for road works the oval eye is recommended. The round eye makes it easier to replace the handle but the blade tends to turn while working.

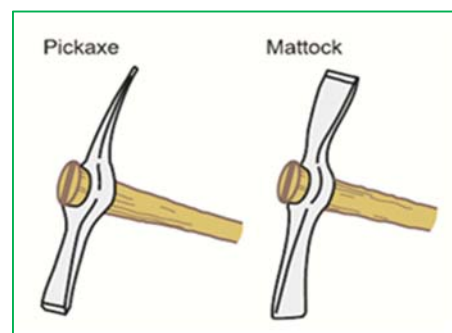
The hoe should therefore have a suitable length handle so that the labourer can work standing upright. The worker should try and stand slightly below the level being excavated.



Pickaxe and Mattock

Pickaxes and mattocks are specialized construction tools for excavating stony, hard soils which are difficult to penetrate with hoes. These tools always have an oval eye so that the handle cannot turn in the eye. Both the pickaxe and the mattock are

rather heavy; the pickaxe usually weighs between 2.7 and 3.6kg and the mattock



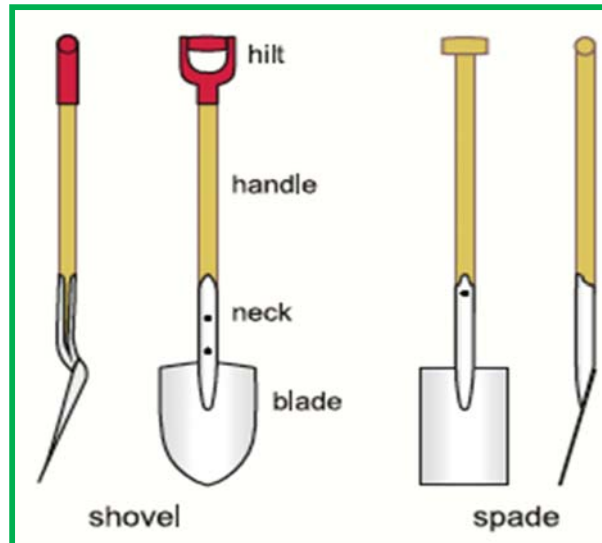
between 1.8 and 2.7kg. As they are double edge striking tools, it is necessary to have a straight handle with an elliptical rather than circular cross-section.

The handle should also be provided with a raised safety grip which prevents the handle slipping out of worker's hands.

Shovel and Spade

Shovels are used for scooping up material and throwing it on to a trailer, truck and wheelbarrow or directly to where the material is needed. The shovel has a rounded or pointed blade while a spade has a square shaped blade which is stronger than that of a shovel. Spades are used to dig the wet clay soils and throw the material to where is needed.

The handle for both tools should be long enough to allow the worker to throw the soil with little effort. Shovels and spades should not have sharp joints which damage the hands of user.



Hand rammer

The hand rammer is used for compacting soil and gravel and consists of a weight with a long handle.



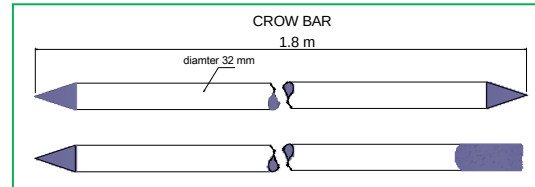
Two aspects determine the effectiveness of a hand rammer: (i) its weight and (ii) the area that hits the ground. Ideally the weight should be as large as possible and the area as small as possible. The weight can be made of various materials such as steel, concrete or solid wood.

A rammer which can be handed by a worker should therefore have a weight of some 6– 8kg and a diameter of the bottom end of 13 – 15cm. The handle must be long enough to allow the worker to lift the rammer without bending his back.

Using hand rammers is expensive and difficult to apply evenly over large areas. Hand rammers are most useful in small and confined areas such as around culverts, pot-holes and other places where it is impractical or difficult to access with rollers.

Crow bars

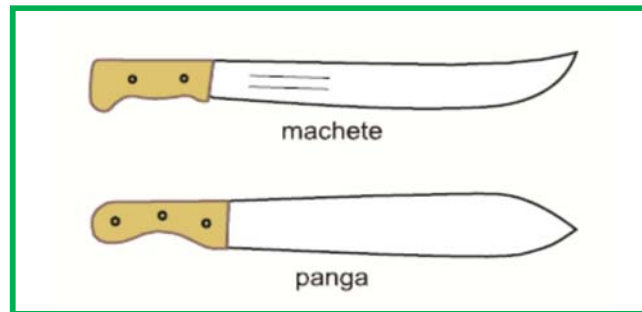
The crowbar, like the pickaxe, is used mostly for digging stony, very hard soils or moving the boulders or heavy things when used in the right way as a lever. The crowbar looks like a simple tool, but it has to be of very strong material that does not bend easily and be well designed to function properly.



Crowbars are usually manufactured either as round or octagonal section rods. For infrastructure work the diameter should be minimum 30mm. The length is required to be within 1.5 to 1.8 metres. The bar is made of carbon steel and should have one pointed and one chisel end

Bush knives

Bush knife is used for clearing the bush along the road alignment. It consists of steel blade and wooden round handle.



Wheelbarrow

The wheelbarrow can be a useful piece of transportation equipment over short distance (up to 200 metres). Wheelbarrows are used at sites in earthworks and structure construction for transport the construction material such as soil, sand, aggregate, stone, concrete etc. Wheelbarrows are made in many different types and qualities. A good wheelbarrow should take a big load (struck capacity approximately 60 to 70 litres) and be easy to balance and tip.



Basket

A basket is designed for carrying soil, commonly is used in South-East Asia. It can be the principle tool for moving soil over short distances.



A typical basket has a pay-load of 5 to 6 kilograms of soil. Basket can be made from local basket making materials or used tyres or manufactured in plastic. Baskets are very suitable for dry soil, and although they are not as durable, they can be fixed with local materials and cost about half the price. Plastic and Rubber Tyre baskets are most suitable for wet soils. Baskets can be carried individually or two can be balanced on a shoulder pole, at the end of ropes, like a scale, depending upon the workers strength and preference. Maintenance baskets can be fixed with local basket making materials like bamboo. Rubber baskets can also be fixed locally. Once broken, a plastic basket cannot be fixed.

Jute Sack Stretcher



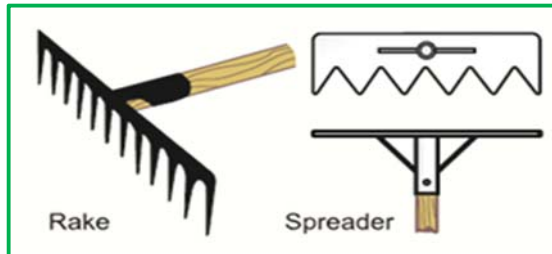
A 'Jute Sack Stretcher' is a locally made device for carrying soil. An empty rice sack (made from Jute fibre), is cut open. Two thick straight bamboo poles about 1.5 metres long are sewn along the length of either side of the cloth, to make a stretcher. The Soil to be carried is placed on the cloth, and the device is carried like a stretcher, hence its' name. The stretcher can carry 3 to 5 basket loads, depending upon its construction and the strength of the workers.

The Jute sack stretcher is made from local materials and depending upon the quality of construction, it will normally last for the duration of a typical road project. It will

require repair, with local materials (usually just string for re-sewing) from time to time.

Spreader

There are numerous variations of rakes and spreaders, all designed for specific purposes. Rakes are used in road works for collecting vegetation from loose soil when grubbing, but can also be used for spreading if the soil is not stony. Commercially produced rakes have 10 to 16 teeth, each about 75-100mm long, with an overall width of about 400-450mm. They require straight handles made of hard wood or metal tubes.



Spreaders are used for spreading out the soil on fills. A spreader can be a heavy-duty rake but the best spreaders are specially made for its purpose. The spreader is very useful when forming the camber and for spreading gravel. The soil or gravel should be raked from the centre line towards the shoulder. They can be made of sheet metal (3-4mm thick) and have a ridge for crushing lumps of soil. Spreaders can be pointed or flat, depending upon the nature of the gravel to be spread.

Maintenance of the spreader: Apart from replacing broken handles, spreaders require little or no maintenance. Cracks in the blade can be welded. Broken rakes can be also welded. If a rake tends to break often, it can be reinforced with a piece of round iron bar, which is welded across the top of the teeth connector.

C-3 Tools for setting out and quantity surveying

Each Company should procure the tools for setting out listed in the table below. These tools should be used for carrying out the setting out of road alignments such horizontal and vertical alignments, cross sections and at the same time estimating the quantity of earthworks involved in the road works.

<i>Type of tools</i>	<i>Unit</i>	<i>Recommended number</i>
Ranging rods	no	20
Profile boards	no	20
Measuring tape 50m	no	2
Measuring tape 5m	no	4
Line level	no	2

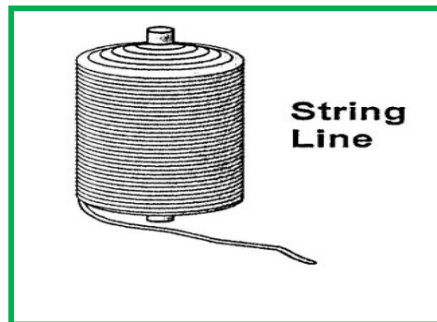
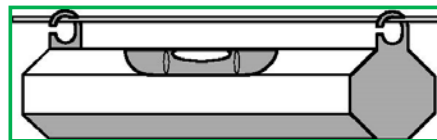
Chisel or crowbar	no	1
Bush knife	no	2
Hammer	no	1
Axe	no	1

Line level and string line

The line level can be used with the string to transfer the exact level of one location to another point, thereby ensuring that both are at the same level. It is easy to carry around and with care and it also can be used for setting out levels and slopes not less than 1 in 300.

The line level is a short spirit level (about 100mm long) with a hook at each end to hang it from a smooth nylon string.

This instrument needs two persons to operate – one at the end of the line, and the second to watch the spirit level.



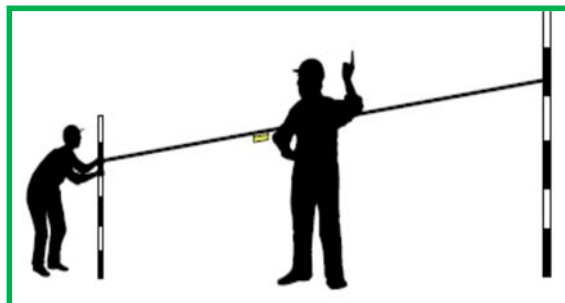
The line operator moves the string up or down until the bubble is centred in the middle between the spirit level marks. The string line will then indicate the horizontal line.

For this purpose the clear nylon string for fishing should be used. It makes easy to move the level along the line to the required position.

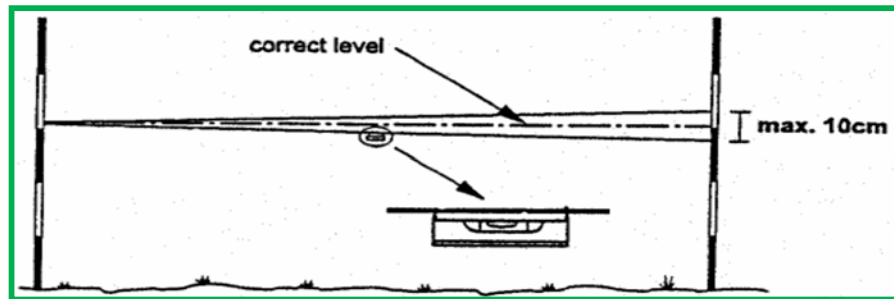
Checking line level

Checking the line level should be done regularly in the field. To check the accuracy of the level:

- ✚ place two ranging rods 10m apart,
- ✚ fix a line on one rod, transfer the level to the other rod and mark this level,
- ✚ keep the line in place and turn the level,
- ✚ adjust the line again and mark the new level,



- ✚ measure the different between the two levels,
- ✚ if difference is less than 10cm, the correct level is exactly in the middle of the two marks, if the difference is more than 10 cm the level should be replaced.

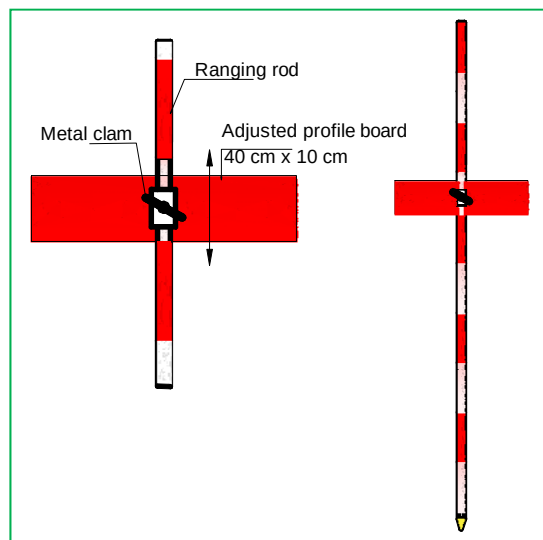


Ranging rod and profile board

Ranging rods are used to set out the straight and curve lines and to support profile boards on both straight and curved sections of the road.

Ranging rods are usually made of hollow metal tube, often 20-25mm diameter galvanized water pipes, with a pointed end of sharpened reinforcement steel and have 2 metres long.

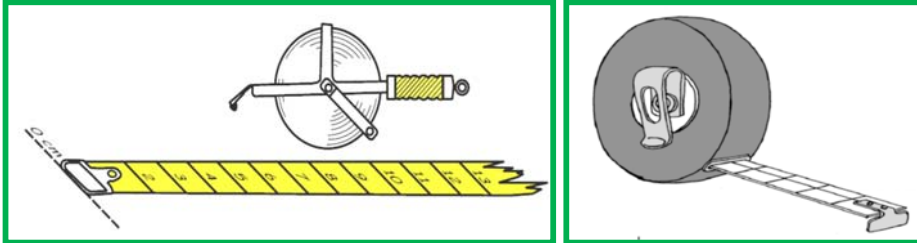
They are painted alternately red and white to make them easy to see during setting out. The length of red/white sections is 250mm. Profile boards are used to set out the road profile in straight grade, sag or crest sections.



A profile board is designed in such a way that it can be attached to a ranging rod. It has a screw mechanism that enables the profile board to slide up and down on the ranging rod and be fixed at any desired point simply by tightening the screw.

Measuring tape

The most common length of tape measures used for setting out is 30m and 5m. The tapes are made of steel or linen. Although the former is stronger, the numbers/markings on the tape becomes unreadable after a period of use. Important is to keep tape clean and avoid dirt from entering the dust.



Note: The zero point is not always located at the same place on different tape measures.

Metal spike/pointed chisel



The metal spike / pointed chisel looks like a simple tool, but it has to be very strong material that does not bend easily and be well designed to function properly.

This instrument is usually manufactured either as round or octagonal section rods. For the setting out the diameter should be minimum

20mm. The length is required to be within 30 cm to 40 cm. The spike is made of carbon steel and should have one pointed end.

This instruments is used with hammer to make a hole before placing the ranging rods and pegs in the ground, when the setting out is carried out in hard and compact soils.



C-4 Quantities of hand tools and survey instruments for Labour-Based road works

Table below shows recommended types and quantity of hand tools for the Labour based road construction to be used by about 150 labourers

<i>Quantity of hand tools for 150 labourers for the labour-based road works</i>		
<i>Items of hand tools</i>	<i>Unit</i>	<i>Quantity</i>
Tali nilon / Nylon string	Kgs	20
Metru 5m / Measuring Tape	Pcs	9
Metru 30m / Measuring Tape	Pcs	2
Kanuru kabuar (liman ai)/ Shovel Wooden Handle	Pcs	70
Karau dikur/ Pick axe	Pcs	70
Ensada / Hoe with handle	Pcs	70
Katana / Bush Knife with handle	Pcs	15
Nivel / Line Level	Pcs	4
Karosa Dudu / Wheel Borrow	Pcs	30
Kado Ai / Wood Saw	Pcs	2
Garfu Estrada / Rake	Pcs	10
Baliu / Axe	Pcs	20
Eskopu / Chisel	Pcs	10
Luvas / Glove	Pcs	20
Masker / Mask Protection	Pcs	150
Safety Traffic Control	Pcs	10
Ai Suak / Crowbar 1.5m	Pcs	20
Ranging rods and Profile Boards	Pcs	15
Staka / Pegs	Pcs	5000
Gravel Spreader with handle	Pcs	30
Martelu / Hammer with handle	Pcs	15

C-5 Light equipment

Equipment for labour-based road works is mainly utilized for operations such as haulage of materials and water, compaction and stone blasting. Well-designed and maintained equipment is important as it determines the productivity as well as the quality of the work carried out. Malfunctioning equipment is very often the most common item which jeopardizes the progress of works.

Pedestrian vibrating rollers are more suitable for use for compaction of rural roads. A 1 tonne twin-drum pedestrian vibrating roller is recommended for labour-based road construction. These can compact soil layers 10-15cm thick. Trials on number of passes, thickness of layer and moisture content may be necessary to define the most effective compaction procedure for different soil types. In mountainous terrain it is difficult to operate and control a pedestrian vibrating roller on steep grades. There it is better to use a riding vibrating roller.



Water bowser: Compaction of the road works cannot be achieved to the required strength without achieving Optimum Moisture Content during compaction. Watering is therefore necessary, especially in the dry season. For the Labour based works, a medium size water bowser with capacity of 3,000 to 5,000 liters is required.



Dump truck: Dump trucks are used for the Labour based road construction to transport construction material such as cement, sand and aggregate for the drainage structures construction. The dump truck is also needed for haulage of gravel for the road surface work when the gravel quarry is not available near the road section. Dump trucks with a capacity of 4m³ are common in Timor-Leste and are suitable for the rural road construction.



LBT Training Manual

Module D

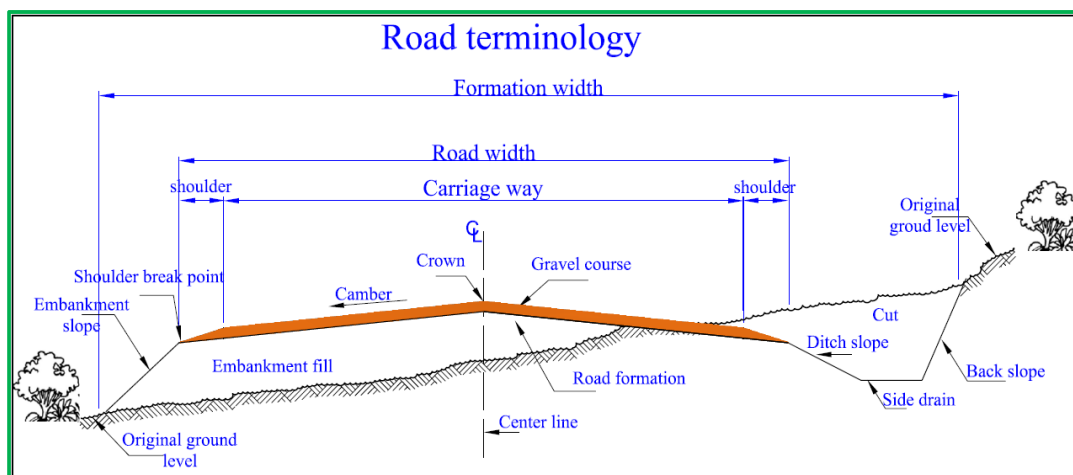
Road

Terminology

Table of Contents, Module D Road Terminology

D	Road terminology	2
D-2	Typical cross section.....	4

D Road terminology

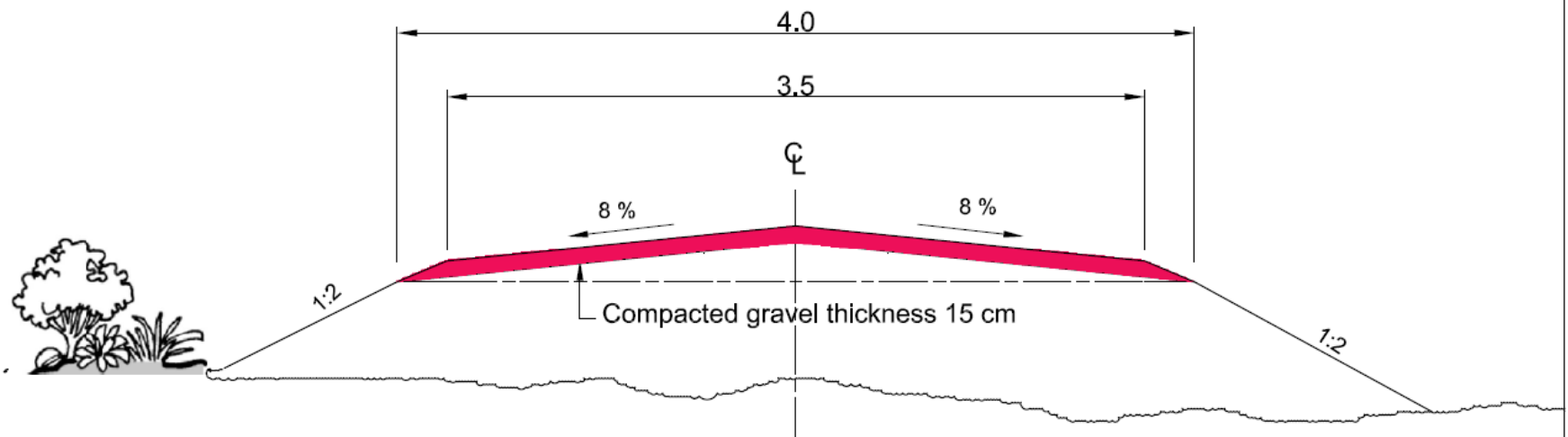


Term	Definition
Formation width	Full width of road including drains and embankment
Road way	Width of road available for traffic, including shoulders
Carriage way	Pave width of road
Shoulders	Paved or unpaved width of road next to the edge of the carriage way adjacent to the ditch or embankment slop
Camber	A cambered road has a cross section like a "Roof" to drain the rain water away from the carriage way of the drains
Gravel course	A layer of compacted gravel which forms the surface (or pavement) of the carriage way
Embankment	Compacted earth fill below the roadway
Cut	Excavation in the natural on the hill side of the road usually with graded slopes. The dug out material is used to fill the embankment on the valley side of the road
Sub grade surface	Upper layer of the soil (natural material) supporting the road way including embankment slopes
Side drain	The side drains run along the road and collect the water from the carriageway and adjoining land and transport it to a convenient point of disposal

Original ground level	<i>The natural surface of the cross section before construction</i>
Back slope	<i>The outer slope of the side drains with an appropriate angle to prevent the soil from sliding to the ditch</i>
Ditch slope	<i>Inside slope from the shoulder to the side drain</i>
Embankment slope	<i>Natural material slope on embankment</i>
Shoulder break point	<i>The junction of the carriageway shoulder with the drainage ditch</i>
Crown	<i>Peak or highest point of the camber</i>
Road center line	<i>Line running along the center of the road (important in surveying and setting out the road alignment). Longitudinal sections usually run along the road centerline</i>
Chainage	<i>Is a term frequently used for describing distance measured along the center line of a road and are shown written on pegs or boards which are fixed in the road reserve</i>



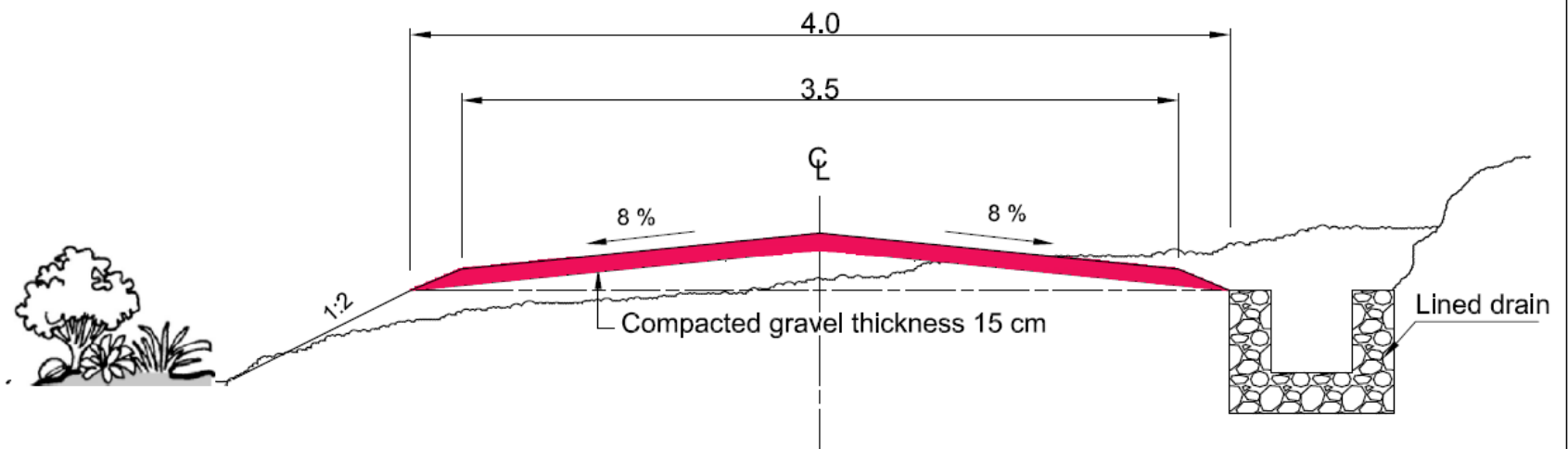
TYPICAL ROAD CROSS SECTION IN FLATE TERRAIN EMBANKMENT



NOTE:

1. All dimensions are in meters unless otherwise specified

TYPICAL CROSS SECTION ROAD IN MOUNTAINOUS TERRAIN



NOTE:

1. All dimensions are in meters unless otherwise specified

LBT Training Manual

Module E

Work

Organisation

Table of Contents, Module E Work Organisation

E	Work organisation	3
E-1	Work site organisation	3
E-2	Labour recruitment for LBT road works.....	4
E-3	Incentive payment system	6
E-4	Planning.....	11
E-5	Construction sequence	15
E-6	Work gang balancing.....	18
E-7	Instructions.....	18
E-8	Inspection of works	19
E-9	Establishment of site camp	20

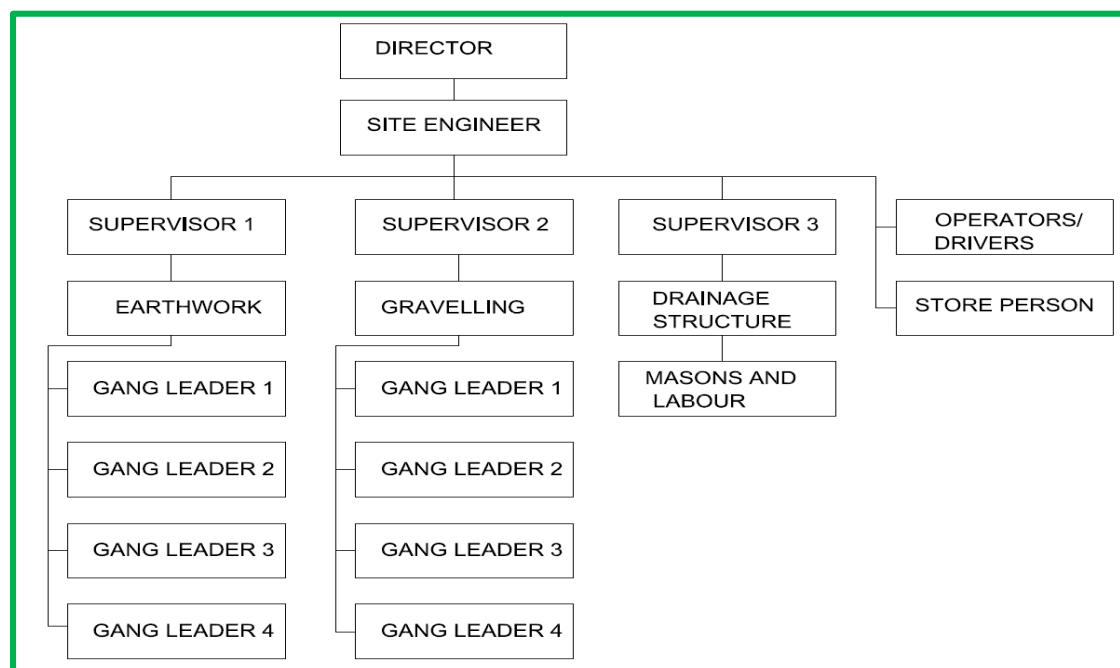
E Work organisation

Most of the works are carried out using local labour and only those activities that labour cannot manage is done using intermediate equipment like light trucks, pedestrian rollers, etc. The end result of the work is expected to be of high quality as stipulated in the contract specifications. ***To achieve work of high quality, and to be able to carry out the work within a given time frame, good site management and structured work approach is required from the contractors. The most demanding task is to manage a large, mainly unskilled labour force.***

E-1 Work site organisation

A labour-based road construction project, with up to as many as 150-200 labourers and a work site that is several kilometres long, needs to be planned and organised carefully. Otherwise it is impossible to ensure high productivity from each labour work gang and an efficient use of each piece of equipment.

Organizing workers for the labour based road construction is a crucial task for the site engineers and site supervisors. Work organisation is to arrange and distribute works between the gangs of workers in such a way that the best use is made of available labour, materials and tools. To effectively manage the labour it is recommended to have a site management structure as shown in the organization chart below:



For the effective management of the labour, one supervisor should not manage more than four gangs of workers and each gang of workers should select one work gang leader to supervise the gang of workers. Selection of women gang leaders are encouraged of 30-40% of the total number of gang leaders. Each work gang should consist of between 15 to 25 workers. The work gang leaders should also be

employed as a casual semi skilled worker. A gang of workers is usually engaged in only one or two different types of activities for each day. All workers in the gang are assigned to work places close together to ensure efficient supervision and control.

As shown in the above site structure if a road construction site need to employ up to 300 workers, a minimum of three site supervisors should be deployed for supervising the works. Each road construction site should have one Site Engineer. The Site Engineer should take full responsibility for the entire work operation which includes both site administrative matters and technical issues.

For the success of the project, the contractor's director should spend a reasonable amount of time at the site to guide and monitor the site staff. Weekly or bi-weekly meetings should be held with the site staff to ensure effective communication and resolution of any problems. All instructions, both technical and administrative, must be confirmed in writing

E-2 Labour recruitment for LBT road works

One of the objectives of the road construction using the Labour-based approach is to involve the local people in the road rehabilitation works as much as possible. The labourers will therefore be recruited from the location(s) where the road is passing. In this way local communities gain the benefits of the road rehabilitation activities.



When the preparation of the road, or section of road, is completed, the site management will move to another location and the casual labour force will be discharged. Casual labourers should not be employed for a continuous period of more than three months. Women will be offered equal opportunity to men for employment and the recruitment process must clearly demonstrate this. Opportunities for employment should also be offered for disabled people. Special activities that they can carry out have to be identified in consultation and allocated to them.

The recruitment of the casual labour force for each site will be carried out in the presence of the local authority and with a public meeting, a week or two before the start of the actual site works. The recruitment will be carried out by the Contractor in consultation with the ERA Engineer and coordination with the local authority.

When the recruitment process fails to obtain the required number of labourers, it is usually because insufficient effort has been made to ensure that as many people as possible know about the recruitment. It is often women, rather than men, who are not advised about employment opportunities in time. Therefore the following procedures are necessary to ensure good dissemination of information about recruitment.

Announcement

The announcement for recruitment of labour for the works should be made in relevant locations, not less than two weeks in advance of the event. The notices should be in local language and posted at churches, schools, markets, health center, water source and other places near the site where they will be seen by a large number of people. The notices should clearly indicate the location and time of recruitment activities and that work is available for women and for men.

The announcement should be delivered to the local radio channel, which can further on announce the available work opportunities through the community radio.

Recruitment

Recruitment of casual labourers should be done about one or two weeks before starting of actual work. The workers should be recruited from people living in the communities in the vicinity of the road to be constructed.

The contractor is responsible for the recruitment of the workers and to follow the employment laws of the country and employment clauses included in the contract. The contractor should coordinate with local authority especially with the Suko Chief and the Sub-district Administrator for recruitment arrangement. A meeting, explaining the objectives of the activity and conditions of work, should be held with the community in the presence of the Suko Chief and Sub-district Administrator. The meeting should provide the information on:

- ✚ Type of work to be carried out.
- ✚ Recruitment process, and that labourers should offer his or her services voluntarily
- ✚ Number of labour to be recruited, and the time and place of recruitment
- ✚ Employment duration and other conditions of work
- ✚ Women and men are equally eligible and welcome to seek employment
- ✚ Minimum working age, and that school must be a priority for young people
- ✚ Wage payment based on task system, timing and arrangement for payment and payment method, stressing equal payment for women and men for work of equal value.
- ✚ Safety and health regulations to reduce the risk of injury and sickness related to the work place,
- ✚ Offered wage
- ✚ Responsibilities of the community and the workers

If there are more job seekers than vacancies then a secret ballot will be made to select the casual workers or use rotation system to give for everyone a chance to access the work. This is important in order to avoid possible accusation of corruption practice. Each casual worker should be registered. *A requirement of the project is that the contractor provides same opportunities for women to work as for men. In practice this means, that half of the workers should be women as long there are*

sufficient numbers of interested and available female workers who fulfill the general criteria for work. However, at least minimum of 30% of the workers should be women.

Labour should be recruited step by step according to the plans and work requirement. The table below shows an example of the labour recruitment planning.

Step by step of recruitment of labour

No.	Activities of works	Step of labour recruitment					
		WEEK-1	WEEK-2	WEEK-3	WEEK-4	WEEK-5	WEEK-6
1	Bush cutting, grass clearing and grubbing	10	10	10	10	10	10
2	Cut to spoil-soft soil		10	15	15	15	15
3	Levelling from cut			10	15	15	15
4	Excavation of side drain				15	15	15
5	Fill for leveling to form Camber					15	15
6	Labour sub contract for drainage structure				5	5	5
	Total labour per week	10	20	35	60	75	75

It is important to train workers on the job at the beginning of implementation on work systems, work procedures and task work implementation. It is also an advantage to keep workers for a longer period of time as they will have learnt on the job making supervision easier.

E.3 Incentive payment system

In order to achieve the planned work in labour-based road construction works, it is necessary to motivate and encourage the labourers by giving incentives. Incentive can vary from one to other project. The incentive can be payment in kind, cash payment, provision of food or a mix of food and cash payment. However, it is recommended to provide cash as the incentive in labour-based work to achieve the desired productivity. There are three basic cash payment incentive schemes in use the labour based road construction and maintenance works, as presented in the table below.

Incentive Schemes for Labour-based Works	
Daily Paid	Workers are paid an agreed sum of money for each working day in return for a fixed number of hours. This system is sometimes used in labour-based road construction for activities which are difficult to quantify. e.g. watering activity, workers who follow the roller during compaction to fill low spot that appear during compaction, etc.
Piece Work	Workers are paid a fixed sum of money per unit of output. The daily output is usually left to the discretion of the workers. Through this system workers can earn more money by increasing daily output. This system requires good control by the supervisors in order to achieve quality of the work as the workers are trying to product more output and paying less attention to the quality of work or safe working practices. For the labour based road construction works, this system is good for some activities, which require less number of worker such as construction of culverts, excavation foundation of bridge, etc.
Task Work	Workers are paid an agreed daily wage in return for a fixed quantity of of work, so called daily task. Workers are free to go home as soon as the given task has been approved. Individual or group tasks can be given. The most successful of the labour-based road construction project have been the organized using the task work system. The task work system is therefore usually recommended for labour-based road construction works. Advantages of the task work system for the labour based road construction works include:  Planning of the work is simple because the output per workday is known;  A higher output than with daily work is achieved because the workers know their task and value the extra free time they are getting;  Supervision is easier because each worker knows very well what to do. The workers are eager to finish work early.

Establish task rates

The task rate system gives the worker one days wage for a defined volume of work. The task must be set fairly and based on the actual conditions on site. It is therefore important to determine task rates of each activity of the road works before the work commences. This can be done based on previous experiences and through empirical studies during the work. Important factors impacting on the task rate include

- ✚ The difficulty of the work, eg soil hardness, bush thickness, etc
- ✚ Condition of the hand tools
- ✚ Temperature and weather conditions
- ✚ The fitness or health of the workers and their experience of work
- ✚ Establishing the task rates should follow steps below:

Establishing the task rates should follow steps below:

- Step 1** Set aside one day for a trial on the activity. Organize the labourers on a day work basis on this activity.
- Step2** Supervise the men/women closely, making sure that they all work hard for an eight-hour period.
- Step 3** Measuring quantity of completed works after 8 hours. This gives an average task rate for the activity.

$$\text{Task Rate} = \frac{\text{Quantity completed in one day}}{\text{Number of workers for this activity}}$$

Repeat this exercise frequently and adjust the task rate so that all labourers work on site for at least six hours. **Task rates are important - keep them fair!**

Task rates (work norm)

The task rate (or work norm) is the quantity of work to be completed by one labourer (or a group of labourers) for one day works to satisfactory quality.

The task rate for the road work activities vary depending on many factors, like geometry general condition at the particular location, type of soil, etc. In Timor-Leste, based on experiences from previous labour-based road project, task rates have been established for each activity of the road works. These task rates should however be reviewed for

each new construction project and also from time to time. The table below shows the established task rates of road construction activities in Timor-Leste:

TASK RATES FOR LABOUR - BASE ROAD CONTRUCTION					
Activity	Unit	Task Rates			Recommend ed work system
		Condi - I	Condi - II	Condi - III	
<i>Setting out of road alignment include road cross section</i>	M/wd	50 - 100			Daily work. Team of 3 skills worker
<i>Bush Clearing include disposal of cleared material out of clearing width</i>	M ² /wd	300	350	400	Task work or small group task (max 5 workers)
<i>Grubbing include disposal of grubbed material out of clearing width</i>	M ² /wd	50	75.0	100.0	
<i>Grass Clearing include disposal of cleared material out of clearing width</i>	M ² /wd	80	100.0	120.0	
<i>Tree and Stump Removal include disposal of tree and stump out of clearing width</i>	No/wd	1.0	2.0	3.0	
<i>Top Soil Removal include disposal of spoil material out of clearing width</i>	M ³ /wd	3.0	4.0	5.0	
<i>Excavation(cut) to spoil include throw the exceeded material out of road formation</i>	M ³ /wd	1.5	2.0	2.5	
<i>Excavation (cut) and fill include spread and level the material</i>	M ³ /wd	1.2	1.5	1.8	Task work or small group task (max 5 workers)
<i>Excavation and fill from borrow (within 30 m) include spread and level the material</i>	M ³ /wd	1.1	1.3	1.5	
<i>Excavation and fill from borrow (within 30-50 m) include spread and level the material</i>	M ³ /wd	1.0	1.2	1.3	
<i>Excavation (cut) of side drain and form Camber</i>	M ³ /wd	1.1	1.3	1.5	
<i>Soft rock Excavation</i>	M ³ /wd	0.8	1.0	1.2	
<i>Forming Camber use material from borrow</i>	M ³ /wd	1.1	1.3	1.5	
<i>Slopping (back slop and front slop) include spread the cut material for road formation</i>	M ² /wd	40.0	50.0	60.0	
<i>Planting Grass</i>	M ² /wd	11.0	13.0	15.0	
<i>Excavate gravel and stock pile</i>	M ³ /wd	1.1	1.3	1.5	

<i>Load gravel on a truck (4 m³ truck)</i>	M ³ /wd	4.0-4.5			
<i>Gravel Spreading</i>	M ³ /wd	4.0	4.5	5.0	
<i>Condition - I : Hard soil, Hard gravel, Hard Rock, Bush, Heavy vegetation and grass cover etc.</i>					
<i>Condition - II : Firm Soils, Medium condition of rock, gravel, bush, vegetation and grass cover etc.</i>					
<i>Condition - III : Sandy soils, loose rock, loose gravel, normal condition of bush, vegetation and grass cover etc.</i>					

TASK RATES FOR DRAINAGE STRUCTURE				
Activity	Unit	Proposed norm in Range	Recommended work system	Remarks
<i>Construction stone masonry head wall, wing wall and abutment wall of culvert include prepare mortar, haul and pointing.</i>	M ³ /wd	0.7- 1.0	Piece work	Min. Team: 1 head mason, 3 helpers
<i>Construction stone masonry lined drain and retaining wall include prepare mortar, haul and pointing</i>	M ³ /wd	0.7- 1.0		
<i>Construction of concrete work for culvert and small bridge include mixing, hauling, placing and curing</i>	M ³ /wd	0.5-1.0		Min. Team: 1 head mason, 5 helpers
<i>Dry stone pitching include prepare base and place stone</i>	M ² /wd	4-8		Min. Team: 1 head mason, 3 helpers
<i>Bend, place and fix steel bars</i>	Kg/wd	100-150		Min. Team: 1 skill bar bender, 2 helpers
<i>Gabion work: Prepare base, fix gabion box, place stone</i>	M ³ /wd	1.5 - 2.0		Min. Team: 1 skill, 2 helpers
<i>Construction scour check include collection of stone and stick</i>	No/wd	4 - 6	Task work	
<i>Note: The realistic task rates within the given ranged has to be decided upon based on site conditions</i>				

There can be circumstances when the average rates given cannot be applied because of special conditions on a site. In such cases, the task rates should be adjusted. This will allow the labor force to get used to the tools and the activity. Also, during these first few days, the workers and work conditions can be studied so that a correct task rate can be found.

A correctly set task should allow 70% of the workers to finish their day's work in approximately 75 per cent of the normal daily working time. The other 15% of

workers can finish the work a bit faster and the rest 15% complete a bit later. Or the majority of the workforce should be able to complete the works in around 6 hours whilst some will take longer and some will be faster.

Payment of workers

The Muster-payroll is a ledger in which the presence or absence of each worker is noted daily. It forms the basis for the pay-roll and is thus a very important document. No erasure or alterations should be made, however, if alterations prove necessary they should be certified by the Engineer, who should put his/her signature on the place where the alteration has been made.

The Muster-payroll should be prepared and updated daily by the Supervisors. The Muster-payroll needs to be checked by the Engineer and Approved by the Director of the Company before the payment claim is submitted. Workers will sign on the Muster-payroll when receiving their payment.

Payment of wages in full and on time of wages to the workers is one of the most important aspects of labour-based work implementation.

The contractors should clearly explain the amounts to be paid and the process for wage payments before the works start. It is essential to make payment to the workers in the correct amount, on time and at location and date agreed with the community, usually near the road project.



Payment to the workers should be made in a fortnightly or monthly basis. Payment should be always made directly to the worker who conducted the work, not to any other party. This means that payment should not be handled through Chief of Suko, nor should it be paid to any representative of the worker. However, the Contractor shall inform the client and local authorities before any payment is effected, and it is advisable to have the Chief of Suko sign on the Muster-payroll to avoid any future disputes. Adequate security arrangements must be put in place when handling payment to the workers.

E-4 Planning

Planning is done almost everywhere and by everyone, from the farmer who figures out what, when, where and how he shall plan to the government, which draws up plans for the improvement of for example the national infrastructure programmes

A labour-based road construction project, with as many as 150-250 labourers and a work site that is several kilometres long, needs to be planned and organised carefully. Otherwise it is impossible to ensure high productivity from each labour

work gang and an efficient use of each piece of equipment.

Proper planning of the works and monitoring of progress are crucial aspects for the successful completion of the project. There are many different types of plans and many different names for them, but usually they are called after the level at which they are to be used and/or their duration, eg there is the overall project plan and there are daily, weekly and monthly site plans, etc.

The overall project works plan is usually a bar chart which is prepared before the works starts. Based on this over all work plan, during the works implementation, more detailed plans are developed to achieve daily, weekly and monthly targets.

Important planning issues to consider include:

- ✚ Overall, are all required **resources** (labour, equipment, material) available and can they be optimally used?
- ✚ What are the **activities** to be done?
- ✚ What **quantities** of work to be considered for each of these activities?
- ✚ What is the **sequence** (order) of carrying out these activities?
- ✚ What **productivity** (guidelines) should be used?
- ✚ What **time** is available
- ✚ **Cash flow** considerations, and timing of cost outlays

Overall work plan

In order to prepare an overall work plan we need to obtain information like:

- ✓ bill of quantity from the contract document
- ✓ list of available personnel, skilled and unskilled workers
- ✓ list of available equipment and hand tools
- ✓ list of material required

With this information we can prepare the overall work plan. The simplest way to prepare the work plan is a bar chart. The bar chart defines various activities and time of start and end of the activities. To prepare the bar chart it is recommended to follow the process below:

Process of drawing up an overall work plan:

- ✚ From the Bill of Quantity list each activity and resources needed to carry out this activity. Activities should be listed in order, based on the sequence of the works.
- ✚ For each activity estimate the number of worker-days (wd) needed, based on the established task rate. Then calculate number of workers to carry out these activities.

- ✚ Estimate required equipment needed to assist to carry out the activities.
- ✚ Calculate time required to complete each activity. Draw the bar chart of each activity from start and end. Then calculate the time to complete the whole project.
- ✚ Re-check the bar chart and decide if any activity takes too long time or if an activity is overlapping with other activity etc. Refine the bar chart until you feel it reflects a practical and achievable work plan.

Below is an example for overall work plan of a road works

Example work plan of a road works

Total Quantity					2014						Percent. complet.	Km	
	Unit	Plan	Actual		Mar	Apr	May	Jun	Jul	Aug			
Earthworks	km	7	2.5	Plan	1	2	2	2			35.0	7	
				Actual	0.8	1.7							
Gravel	km	7	0	Plan	Plan Earthwork			1	2	3	0.0		
				Actual									
Lined drain	m	200	70	Plan	50	50	50	50			35.0	6	
				Actual	30	40							
Culverts	no	10	3	Plan	1	3	3	3			30.0	5	
				Actual	1	2							
Drift	no	2	1	Plan		1		1			50.0		
				Actual		1							
Gabion	Box	100	0	Plan				50	50		0.0	4	
				Actual									
Cumulative Up to This Month													
	Unit	Plan	Actual										
Earthworks	km	3	2.5	Plan	1	3	5	7			84	3	
				Actual	0.8	2.5							
Gravel	km	0	0	Plan				1	3	7			
				Actual									
Lined drain	m	100	70	Plan	50	100	150	200			70	2	
				Actual	30	70							
Culverts	no	4	3	Plan	1	4	7	10			75	1	
				Actual	1	3							
Drift	no	1	1	Plan		1	1	2			100		
				Actual		1							
Gabion	Box	0	0	Plan				50	100			0	
				Actual									
Remark:													
Planned:													
Actual:													

To support for the preparation of overall works and site management, a labour plan should be prepared as example below

Example of a labour plan

Sl	Description of works	Unit	Quantities	Task rate	Work-days(WDs)	Number of worker	Number of days	Month -1				Month -2				Month -3				Month -4			
								W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4
1	Setting out	M	3000	50m/Wd	60	3	104																
2	Clearing	M2	26400	80M2/Wd	330	10	33																
3	Leveling	M3	900	2M3/Wd	450	10	45																
4	Side drain excavation	M3	1710	1.5M3/Wd	1140	25	46																
6	Filling embankment	M3	200	1.5M3/Wd	133	5	27																
7	Cambering	M3	800	1.3M3/Wd	615	25	25																
8	Excavate and stock pil of gravel	M3	1512	1.5M3/Wd	1008	35	29																
9	Load and unload laterite	M3	1512	3M3/Wd	504	25	20																
10	Spreading of laterite	M3	1260	4M3/Wd	315	15	21																
	Finishing activities	Ls	50		50																		
Total					4806			13	13	23	23	58	58	79	74	56	68	63	28	15	5		

Remember:

- The bar chart shows how the various operations fit together
- Always review and update the bar chart during implementation of the work
- Make sure to monitor the performance of the different activities against the work plan
- Discuss the overall work plan, the bar chart, and the actual progress with the supervisors and engineers every week.
- If the progress falls behind the work plan, identify causes for this and find solutions to the problem in order to catch up with the overall the work plan

Daily plan

The Daily Site Plan is the most detailed of the plans. It outlines which activities will be executed, how many workers will work on each activity and the quantity of work they should do on a daily basis.

The supervisor must always plan ahead by at least one day. After the workers have completed their daily work, the supervisor records the outputs achieved on each of the activities at the end of working day. Based on the production achieved, a plan for the following day is prepared. This plan sets the daily production targets for each of the planned activities.

To prepare this work plan properly, the supervisor needs to know what has happened on the site before. Without information such as what resources were needed to produce a given output, why certain targets were not met, etc., proper planning is impossible. To get the right information on time, a well functioning

reporting system is required.

It is the responsibility of the supervisor to prepare and execute the Daily Site Plan.

The basic information for the Daily Site Plan is

- ✚ Planned and actual quantities of work for the major construction activities (clearing, excavation, ditching, sloping and cambering, etc.),
- ✚ The estimated productivity (task) rate,
- ✚ The resources (number of workers and tools) available.

E-5 Construction sequence

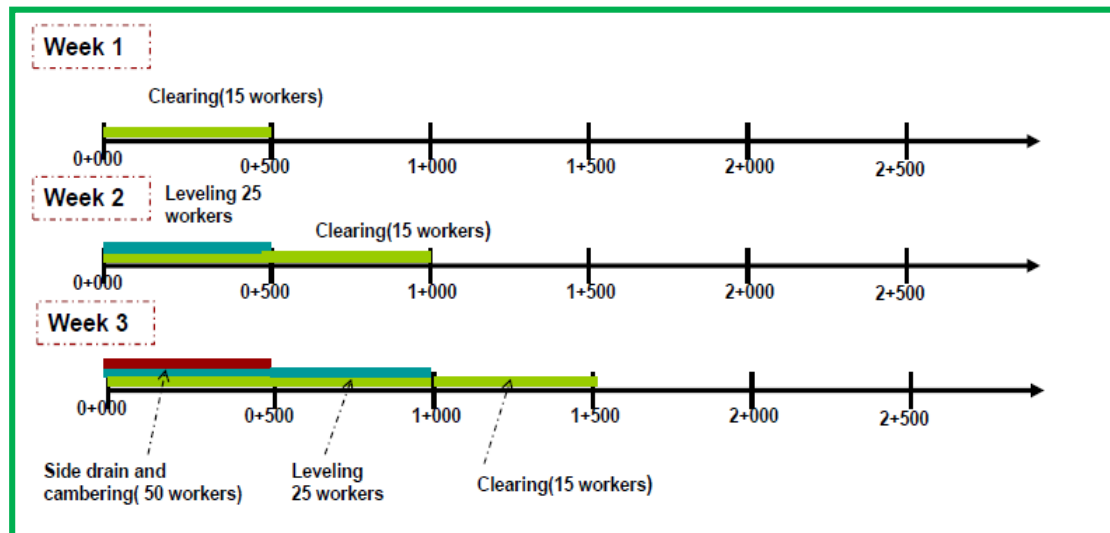
Road construction and rehabilitation works are divided into a number of **operations**, each operation is sub-divided into a series of **activities**. The separate operations on a construction site have to follow each other in a logical sequence. The table below gives a general view of the works sequence on a road construction or rehabilitation site:

	<i>Operation</i>	<i>Activities</i>
Earth Road Construction	<i>Supporting</i>	• Store work (receiving, storing using) • peg fabrication • Tool repairing control • Cook • Guard
	<i>Setting Out</i>	• Setting out horizontal alignment • Setting out vertical alignment • Setting cross section • Setting out drainages
	<i>Clearing</i>	• Tree cutting and stump removal • Bush and grass clearing • Removal of unsuitable material • Boulder removal
	<i>Slotting and Excavation</i>	• Slotting or profiles • Excavation to level

	<i>Leveling and Benching</i>	• Excavation and filling • Step cutting and fill soil for benching • Watering and compaction
	<i>Side drain and Camber</i>	• Ditching • Slopping • Cambering • Compaction
	<i>Other drainage and Scour checks</i>	• Excavation mitre drains • Excavation catch water drain • Construction scour checks
	<i>Erosion control</i>	• Planting grass
Graveling	<i>Quarry works</i>	• Excavation and Stockpiling
	<i>Loading and Unloading Spreading</i>	• Reshaping of sub-grade to be graveled • Spreading gravel • Watering and compaction of gravel

Normally, each activity is carried out by a separate group of workers. If the activities are too close to each other, the work might be disrupted (e.g. an excavation gang might have to wait for a clearing gang to finish). On the other hand, when activities are spaced too far apart, the length to supervise and movement of equipment will become unnecessarily long.

The example below shows work management based on sequence of work activities:



The above chart can be interpreted as follows:

Week 1.

- Clearing activity from Ch 0+000 to 0+500. Number of workers for the clearing operation = 15 workers.
- Total number of workers per day in week 1 = 15 workers

Week 2.

- Clearing continues from Ch 0+500 to 1+000. Keep same number of workers of 15 workers.
- Start leveling activity from Ch 0+000 to 0+500 = 500m. Number of workers for the leveling activity = 25 workers
- In week 2 there are two operations: (i) clearing and (ii) leveling. Total number of workers per day is $15+25 = 40$ workers.

Week 3.

- Clearing continues from Ch 1+000 to 1+500. Keep same number of workers of 15 workers.
- Continue leveling work from Leveling from Ch 0+500 to 1+000. Keep same number of workers of 25 workers.
- Start new operation ditching and forming camber from Ch 0+000 to Ch 0+500. Number of workers for ditching and cambering operation = 50 workers

- In week 3 there are three operations: (i) clearing, (ii) leveling and (iii) ditching & forming camber. Total number of workers per day is $15+25+50 = 90$ workers.

E-6 Work gang balancing

To be able to control the work, it must be split into simple operations. Each operation is then usually assigned to a separate labour work gang with its own work gang leader in charge.

Balancing is to divide the labour force between the different operations and activities so that each operation and activity can proceed as well as possible without causing problems for other operations activities.

Balancing of work gang sizes, i.e. ensuring that the labour is used in the most efficient way, and that each of the operations on average proceeds at the same pace, is the daily task of the Engineer.

Good work gang balancing is important because it also determines the length of the construction site. If the work gangs are not well balanced, the result may be that the work site spreads out and becomes too long to supervise in an efficient manner, or that it becomes too concentrated and the workers are working in a small and congested area. Therefore, there will be a demand for adjusting the number of workers in each gang.

E-7 Instructions

Receiving and giving instructions is part of the Engineer's everyday work. Every plan leads to instructions, i.e. telling someone what should be done, when, where and how.

The manner in which the instructions are given influences enormously the manner in which

they will be carried out. Before you give instructions, you must know:

- ✚ What work you want to have done, how it should be done,
- ✚ Who should do it,
- ✚ The difficulties involved in doing it.

Instructions can be given either directly to the person who is doing the work or indirectly, e.g. through a work gang leader and demonstrations.

- ✚ **Direct instructions:** Should be used as much as possible, especially when artisans such as masons or carpenters are involved.
- ✚ **Indirect instructions:** Can be given through a work gang leader when he or **she** as well as the laborers concerned are familiar with the task.
- ✚ **Demonstrations:** If the task is not familiar, the supervisor should demonstrate how the work should be done by actually doing the work for a short period. This is the best way to make the instructions understandable. It is always important

to use simple words and clear expressions. Since some people do not wish to admit that they have not understood, it is wise to check if the instructions have been understood.

E-8 Inspection of works

The Engineer needs to inspect and approve the work before the workers are released for the day. He should be notified by the work gang leader or worker, who informs him that a particular task has been completed and is ready for inspection.

If the work has been satisfactorily completed, the group or individual may be released for the day. If the work is not complete, it should be corrected before the group or individual worker is allowed to leave the site.

If the task is not completed before the end of the normal working day, the Engineer needs to find out the cause of the delay whether the cause lies with the workers or with his own setting of the task. If the reason for non-completion is one of the following, the workers should be released at the end of normal working day:

-  Major difficulties not considered when the task was set (i.e. heavy roots, big rocks, etc.),
-  Incorrect measurement or calculation of the task,
-  Smaller work force than ordered (if a group task was set),
-  Bad weather conditions during parts of the day.

Remember:

-  Workers should be registered on the muster roll when they have completed their daily task
-  If the reason for non-completion lies with the workers, they should complete the task before being released, even if it is after the end of the normal working day.

If necessary, the workers may return to the work site the following day to complete their task.



E-9 Establishment of site camp

A site camp should be established before work commences. The location of the camp should preferably be half way along the road section for earth road rehabilitation or close to a quarry for gravelling. Existing bad road and access conditions may however affect this decision.

The site camp is where the project site staff live, materials, tools and equipment are kept. The size of a camp for the labour based road works depends basically on the number of workers employed.

Selection location for the site camp

Location for establishing the site camp should be selected based in the following manners:

-  To be within walking distance of all works. The distance from the camp to the furthest working place should not exceed 4km. For roads longer than 8 km, the camp needs to be shifted.
-  To be situated on a well-drained location and if possible not in a depression.
-  To be close to a water source.
-  To be large enough to contain stores, site office and if necessary staff accommodation including latrines.
-  Camps for major structural works (drifts, bridges) should be next to the site to avoid hauling construction materials.

-  Preferably to be located away from villages and markets centers but not so far as to cause unnecessary problems with the purchase of food, etc.
-  To be accessible to project vehicles.
-  Not be located by cemetery, cultural, religious, archaeological or other sensitive or protected areas

Infrastructure and equipment

The size of the site camp depends on the kind of work to be undertaken and on how many people need to be accommodated on site. In some cases the contractors might prefer to rent building which is available on site that might cost lower than building the movable site camp

In case of need to build the site camp, consideration should be taken on movable field huts provide the best comfort and security. On average the following huts are required:

-  There must be accommodation for the site technical staff. This may consist: accommodation for site supervisors and engineer, accommodation for plant operators and accommodation for skills labors
-  Latrine(s) and bathroom hut for the site technical staff. Ideally there should be a separate latrine for men and for women
-  Site office, where all site records including plans, reports, diary, forms, instructions etc are kept. The office will also be used to execute administrative activities.
-  All stores must be stacked neatly so that they can be easily counted, located or collected. Stores also need to be carefully located for safety of workers and to prevent any damage of the items. Stack different stores and sizes separately. All stores must be kept in accordance to the instructions of a supplier, or as directed by the Engineer. Equipment may be stored outside but within the camp enclosure. A separate store for fuel and lubricant for the equipment must be provided separate from the hand tools and material. It is advisable the store for fuel should be away from accommodation and the store for the hand tools and material.
-  A site fence should be provided. Access to the site camp must be route through a lockable gate. If this is not possible, then a security at the entry is mandatory.

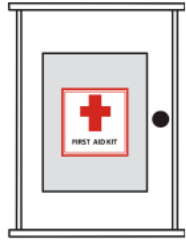
The site camp should be established and fully equipped before commencing the first road construction activity.

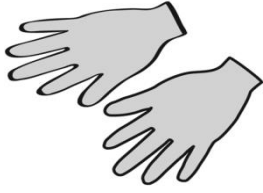
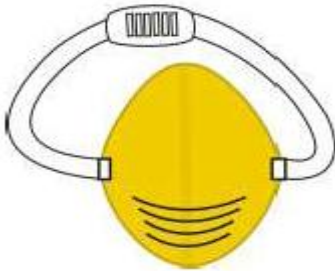
In addition to the site technical staff a trustworthy store keeper should be recruited to keep records of distribution hand tools, construction material and fuel for the equipment.

A watchman should be employed for the security reason around the camp and the staff, the material, tools, fuel and equipment. The watchmen can also assist to repair hand tools and preparing pegs for the setting out.

First aid kit must be stocked and available in the camp in all time when ever emergency need and must be accessed to all staff. The first aid kit should include. For example: Plasters, Bandages, Disinfectant, Antiseptic cream, Clean fresh water for washing eyes, Saline, Irrigation syringe, Sterile dressings, Adhesive tape, Scissors, Disposable gloves, Condoms. Furthermore, the Contractor shall stock appropriate safety equipment, e.g., earplugs or headgear to mute noise from very loud equipment; masks for workers exposed to large amounts of dust; safety glasses for workers doing jobs that may generate sharp projectiles

Table below shows necessary safety gears to be used on site

<i>Description</i>	<i>Safety measures and safety gear</i>
First aid kit must include items like plasters, bandages, disinfectant, antiseptic cream, clean fresh water for washing eyes, saline, irrigation syringe, sterile dressings, adhesive tape, scissors, disposable gloves. The First Aid Kit must be available on site, regularly checked and restocked	
Markings and detours Place warning signs or cones at each end of the work area. The warning signs should be placed 50-100 m away from the working areas. The text on the warning signs should read: "KUIDADU" or "HALAI NENEIK" Deep excavations (more than 1.5 m) for foundations etc shall be clearly marked and fenced off in a way that people cannot drive or fall into the excavation.	
Safety Goggles should be used when there is a risk for eye injury, eg when: • breaking rocks • welding	
Boots should be used when: • mixing concrete and mortar • working in wet or muddy places • working with sharp tools Closed shoes should be worn at all other times	

<u>Gloves</u> should be used when: • carrying heavy load and when using hand tools • working with concrete and masonry work (rubber gloves) • bending and fixing steel bars • breaking rocks	
<u>Safety hat or helmet</u> should be used when working in dangerous of falling objects like: • in deep drain or foundation excavation • under bridge • under tall tree	
<u>Bright vest</u> should be used by site supervisors to easily identifying who is responsible on the worksite. If working on a road with frequent traffic then all workers must wear a safety vest.	
<u>Masks</u> are used when working in places that produce a lot of dust or bad smell.	

Site camp and the environment

The site camp can if not properly planned and managed damage the local habitat, contaminate surface water and generate trash due to lack of solid waste management. It is therefore very important to explore and agree on site camps with the contractor.

The Contractor shall

-  Keep camp size to a minimum
-  Provide potable water for staff and workers
-  Provide temporary sanitation on site

-  Provide hygiene and health information to its crew and community at large, including information about transmission of STDs
-  Collect all solid waste and dispose off in local dump or landfill
-  Prevent fuel tank leaks
-  Restore site through re-vegetation and similar measures after site is broken down

LBT Training Manual

Module F

Setting Out

Table of Contents, Module F Setting Out

F	Setting out	3
F-1	Selection of road alignment	3
F-2	Setting out straight lines	4
F-3	Setting out horizontal curve.....	5
F-4	Setting out vertical alignment.....	7
F-5	Setting out cross section	16
F-6	Set out cross section side drain and camber in rolling terrain	18
F-7	Set out cross section road in mountainous terrain.....	19
F-8	Set out cross section of embankment (road in flat terrain).	20

F Setting out

F-1 Selection of road alignment

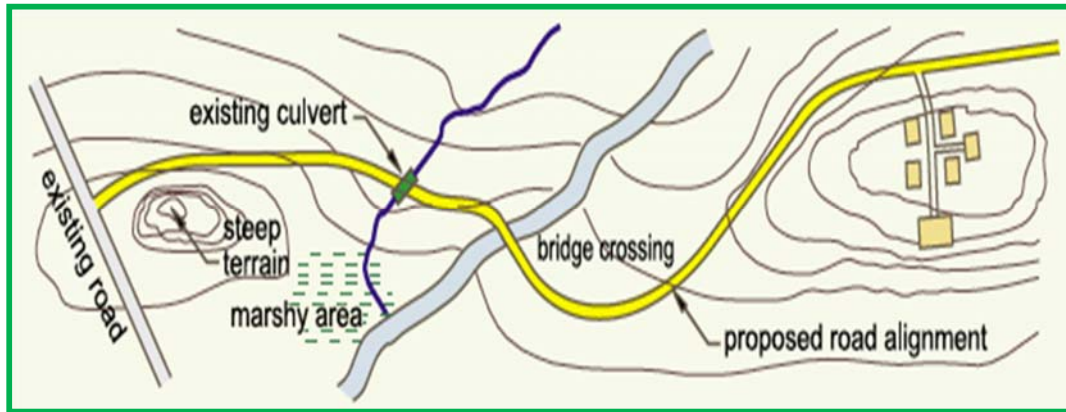
Selecting the centre line of road is the most important duty of the Road Engineer. If the wrong alignment is chosen, it can result in delays to construction or rehabilitation works, over-use of workdays and a road that is difficult and expensive to maintain.

When selecting the road alignment you should consider the following factors:

- ✚ avoid that the alignment cut through villages, farms or other public or private property. In most cases, this is not acceptable, as it would destroy crops, buildings and public facilities;
- ✚ in hilly or mountainous terrain, try to avoid steep gradients. The gradient should not be greater than 10 % otherwise the required cutting earthworks will be excessive;
- ✚ avoid alignments that pass through difficult terrain such as rocks, swamps, dense forest, etc., as this will lead to increased construction costs;
- ✚ if a river or other obstacle has to be crossed, it is necessary to establish an alignment which provides a crossing at the most suitable location. The crossing should preferably be 90° of the road alignment;
- ✚ try to avoid more complicated cross drainage structure;
- ✚ try to follow the existing road alignment. This will help us avoid many problem as well as reducing the costing;
- ✚ avoid triggering soil erosion.

Good selection of the centre line is the best way to save workdays - try to avoid areas that will consume a lot of workdays overcoming natural obstacles.

The centre line selected is a compromise between a number of problems and you will have to work out how you would solve each of these problems, and the amount of work involved. For example, you could avoid an expensive structure by means of a longer route that went round the water course. You would have to consider the cost of the structure against the cost of the extra road works.

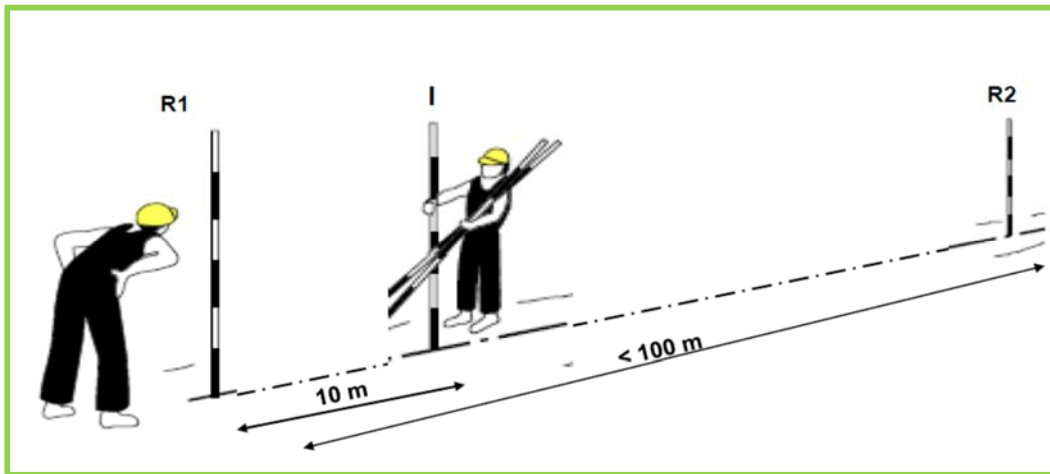


F-2 Setting out straight lines

Straight lines are set out by marking points every 50m to 100m with ranging rods. Between these ranging rods, intermediate points are set out at every 10m. Normally, sections of not more than 50 to 100m are set out at the time. In mountainous terrain, sections of less than 50m may be chosen.

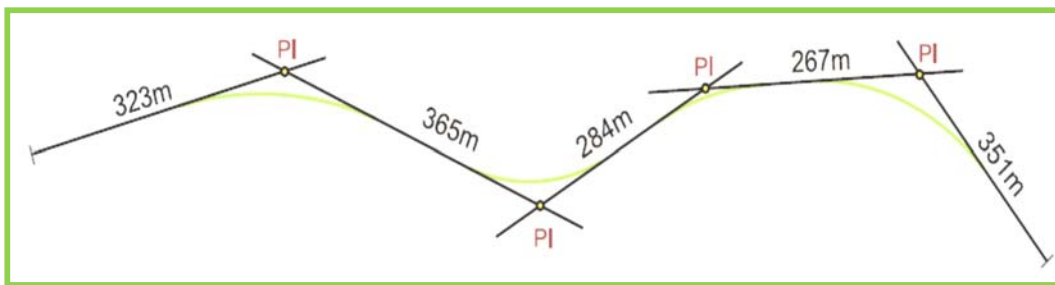
To set out a straight line you should follow the following steps:

- ✚ **Step 1:** Place the first ranging rod at the beginning point of the section and place the second ranging rod at the end point. The distance between the first and the second ranging rods should not be more than 100m. These two ranging rods are called Reference ranging rods (R1 and R2).
- ✚ **Step 2:** One person sight from first ranging rod (R1) to the second ranging rod (R2). A second person places a third ranging rod at the distance of 10m from R1, between R1 and R2. The third ranging rod shall be adjusted to a straight line of R1 and R2. The third ranging rod called Intermediate ranging rod.
- ✚ **Step 3:** Repeat the same exercise by removing the intermediate ranging rod to another point between the R1 and R2 for every 10 m and we will achieve straight line between R1 and R2.



F-3 Setting out horizontal curve

Your centre line has now been selected by means of a series of straight lines meeting at points of intersection (PI). Eventually, these straights will be joined by curves that will be set out during the detailed setting out.



Measure the distance between the intersection points and keep this as a first estimate of the length of the road to be constructed.

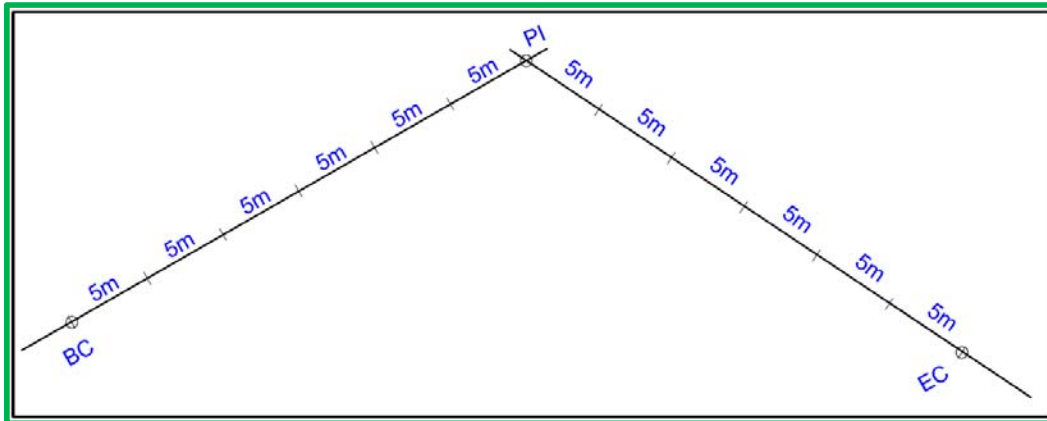
Intersection Method

This method is a simple and effective method to set out curves. It requires simple equipment and can be easily understood by the setting out team.

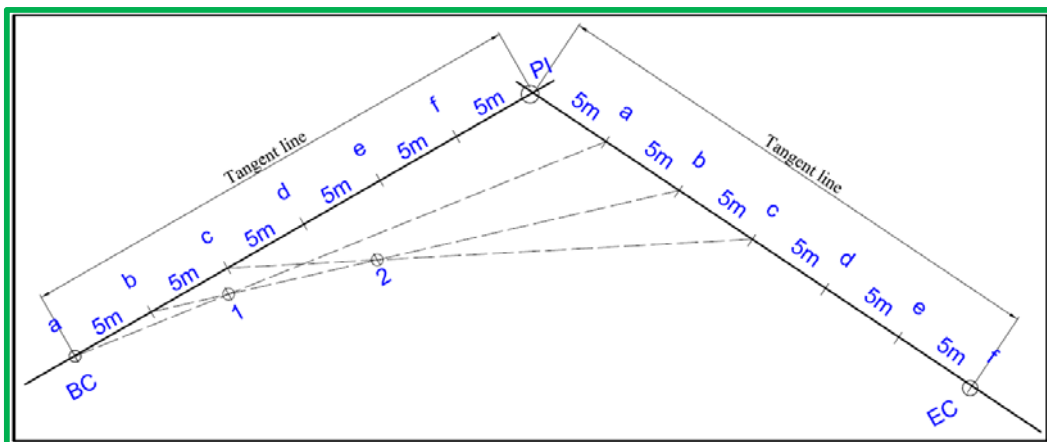
With longer tangent lines you will achieve a longer curve with a larger radius. Deciding the length of the tangents is best done by experience. You will gain experience in how to select the best tangent length.

Setting the horizontal curve should follow the following steps:

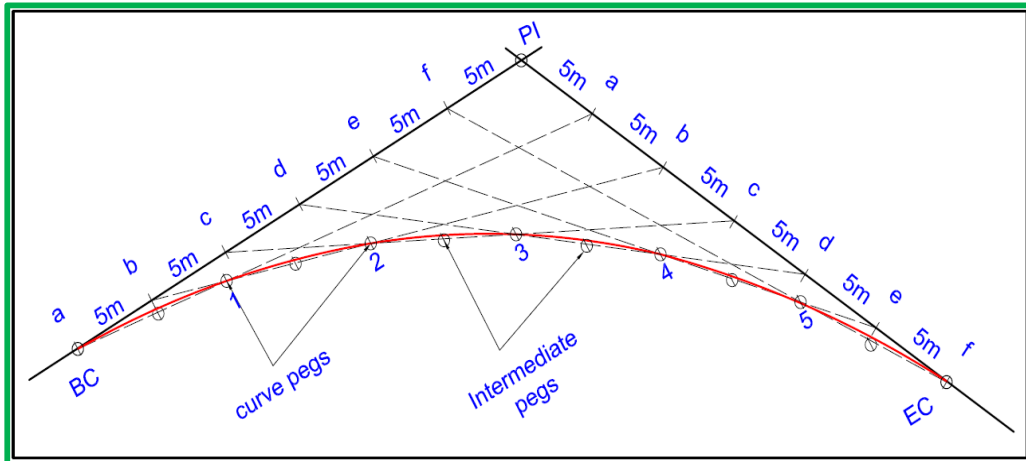
- ✚ **Step 1:** Select the Beginning point of the Curve (BC) and the End point of the Curve (EC). Divide the section between the BC and the PI (meeting point) into equal sections (the more sections the smoother the curve). Then divide the distance between the PI and the EC into equal sections. Note if BC to PI divided into 5 sections and the EC to PI has to be divided in 5 sections equally.



- ✚ **Step 2:** Set point a, b, c, d, e, and f as shown in the drawing below. Sight from point "a" to "a" or use string line to connect from "a" to "a" and then connect from point "b" to "b". The meeting point of a-a and b-b to set a peg as point "1". Repeat the procedure for point "c" to point "c". The meeting point of b-b and c-c to set a peg as point 2.

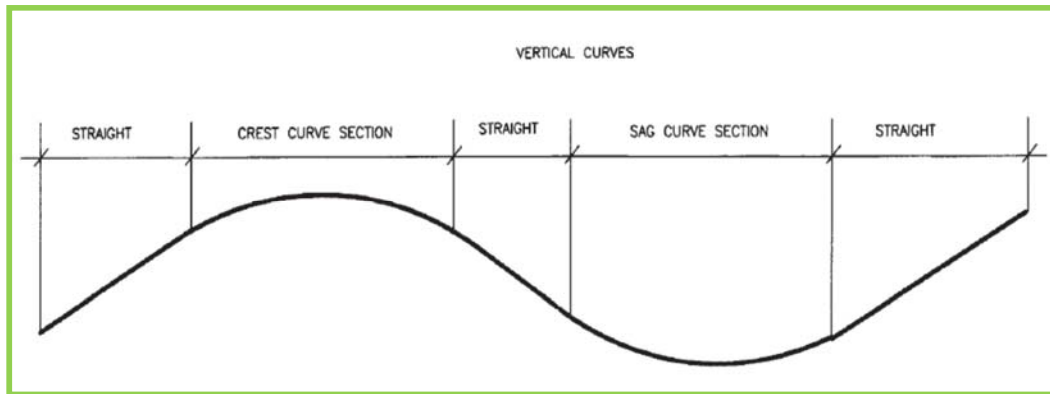


- ✚ **Step 3:** Continue the same exercise for other points until point "f". We have achieved a curve through pegs 1, 2, 3, 4, and 5. Finally, use these curve points to set out pegs at intermediate points along the curve at middle point of each curve peg. Adjust the intermediate pegs until achieving a smooth curve line.



F-4 Setting out vertical alignment

Once the horizontal road alignment has been established, the next step is to set out the vertical alignment, by fixing the level of the road at appropriate intervals along the centre line. The setting out vertical alignment is important as it will have a direct bearing on the construction cost, operating cost of vehicles and number of accidents.



Volume of earthwork cut or fill depends very much on the setting out of the vertical alignment. Careful selection of the reference points (R) during the setting out of the vertical alignment will reduce the volume of the earthworks and will mean that cost of the earth works will be reduced.

Soil excavation is the main activity in this work. To calculate the quantity of this activity, the technical staff should carry out the setting out of vertical alignment and cross sections by using ranging rods, profile boards, line level, measuring tapes, string line and pegs.

It has been noticed that, in mountainous terrains that the cut activity and setting out of curve (horizontal & vertical) are encountered almost the whole of entire road length. It is very complicated for the setting out activity

When setting out the vertical alignment, the following points must be carefully considered:

- ✚ Good correlation with the horizontal alignment.
- ✚ Provision of adequate sight distance over all crests.
- ✚ Avoidance of very short sag curves.
- ✚ Avoidance of a short grade between two crests or two sag curves.
- ✚ Avoidance of a short drop immediately before a long grade.
- ✚ Avoidance of the combination of two vertical curves in the same direction (such must be replaced by a single curve).

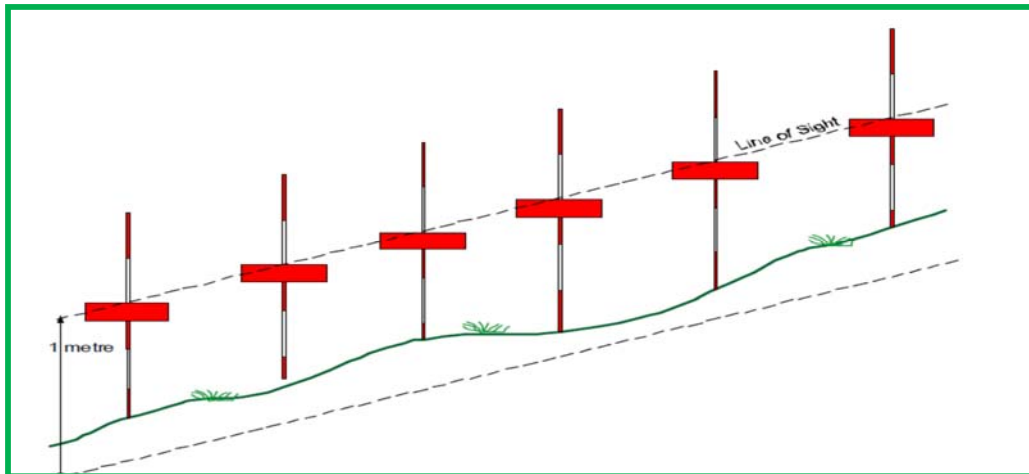
The overall procedure for setting out vertical curves is summarized below:

- (i) Setting out straight grades
- (ii) Setting out gentle vertical curves
- (iii) Setting out the sag to join the straight grades (for larger vertical curves)
- (iv) Setting out the crest to join the straight grades (for larger vertical curves)

(i) Setting out straight grade

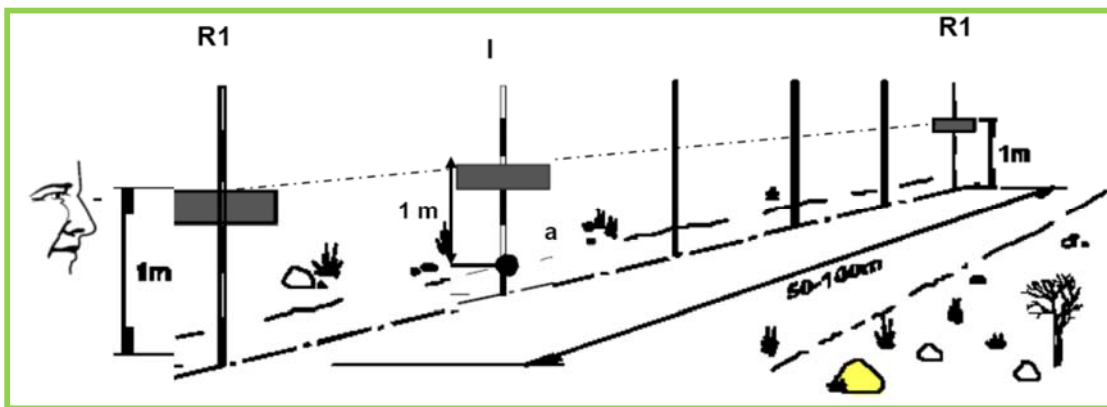
The vertical alignment sets out the level of the road in relation to the surrounding terrain. The cut and fill method in longitudinal section is based on the use of profile boards to set out the straight grade to optimize the road level, avoiding unnecessary soil transportation along the road.

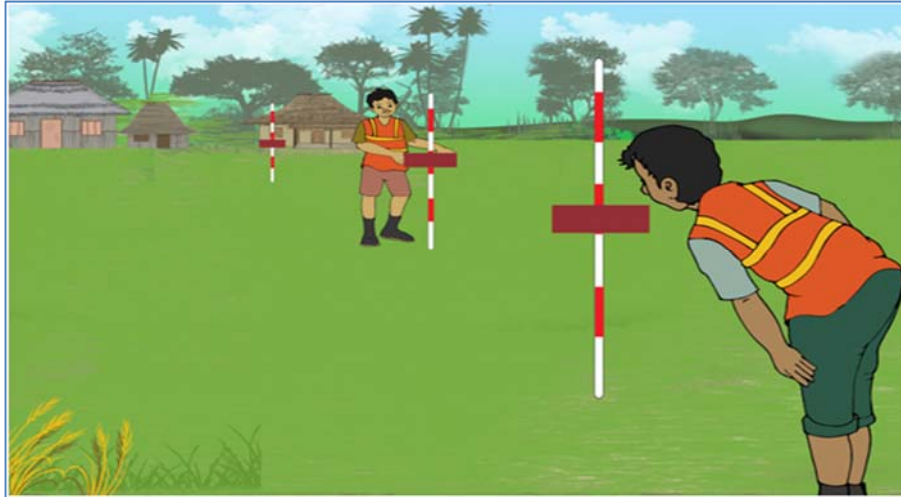
A straight grade is a section of road where the longitudinal gradient of the road centre line is constant.



To set out the straight grade should follow the steps below:

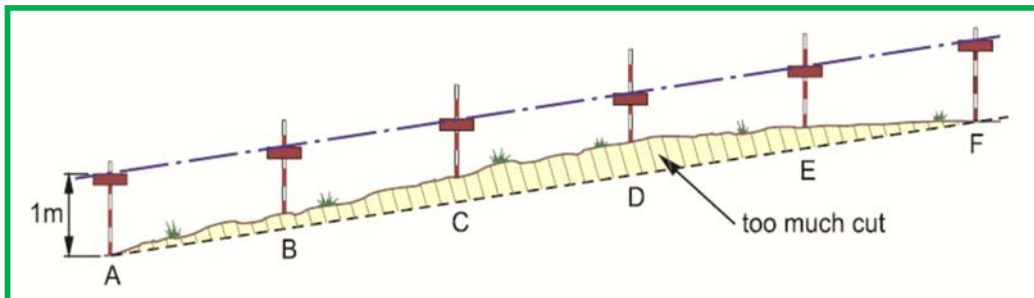
-  **Step 1:** Place two profile boards at two selected reference points, one at the beginning as R1 and the second profile board the end point as R2. The profile boards R1 and R2 are called Reference profile boards. The distance between the two Reference profile boards R1 and R2 should not be greater than 100m.
-  **Step 2:** Fix the profile boards R1 and R2 1 m above ground level firmly as reference LEVEL.
-  **Step 3:** A person sight at the R1 profile board. A third profile board called Intermediate (I) profile board to be placed at between the R1 and R2. The first I profile boards should be placed at 10m from the R1. A second person to adjust the I profile board as instructed by the person who sight at the R1. This to make sure that the LEVEL of the I profile boards and the level of R1 and R2 are the same.
-  **Step 4:** Measure 1.0 m down from level of the I profile board and mark the level on a peg by a permanent pen maker.
-  **Step 5:** Continue the same exercise for every 10m in between the R1 and R2 we will achieve a straight grade in the between the point R1 and the point R2.



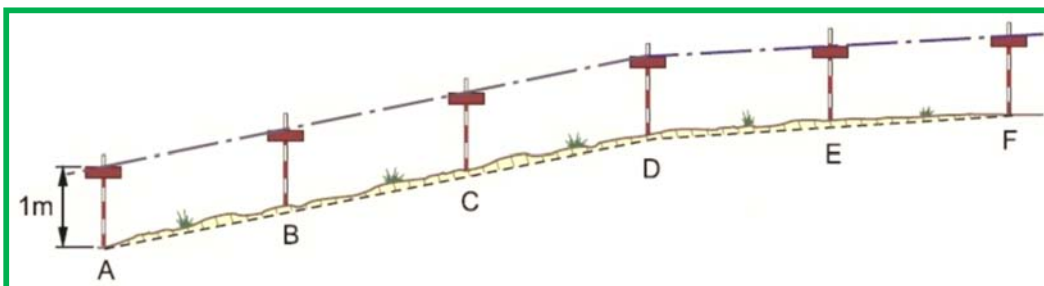


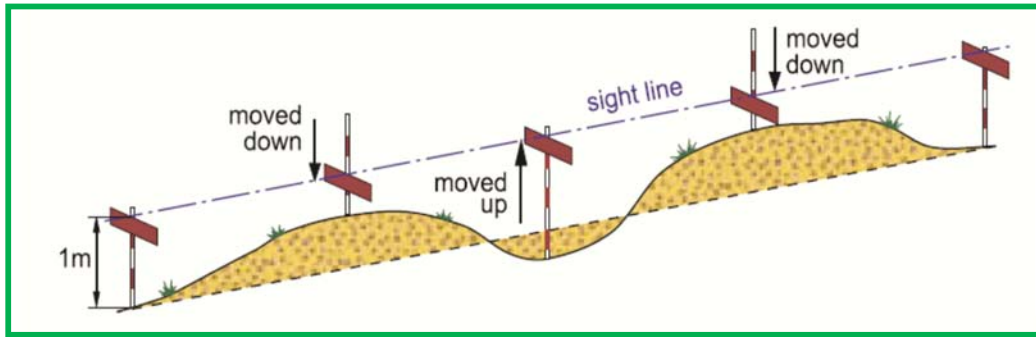
Note: It is important to be bear in mind that the selection of the reference points, (R1) and (R2), is very crucial as quantity of earthworks for cutting or filling will be based on the selected level of the Reference points.

Attention should be given if the height measured from the ground to the Intermediate profile boards is greater or less than 1m by 20 cm, then the cutting too much. In such cases, it is necessary to adjust the profiles to avoid too much excavation works. if the height measured from the ground to the Intermediate profile board is approximately 1m, there is no need to adjust them and you can use the level of the profile as it is.



The above figure shows that the cut area at the "D" is too much. It is recommended to adjust the profile boards at position "D" to raise to 1m above the ground and then lift the profiles at B, C and E to sight in line with the profiles at A to D and D to F. This exercise will reduce the amount of excavation works.



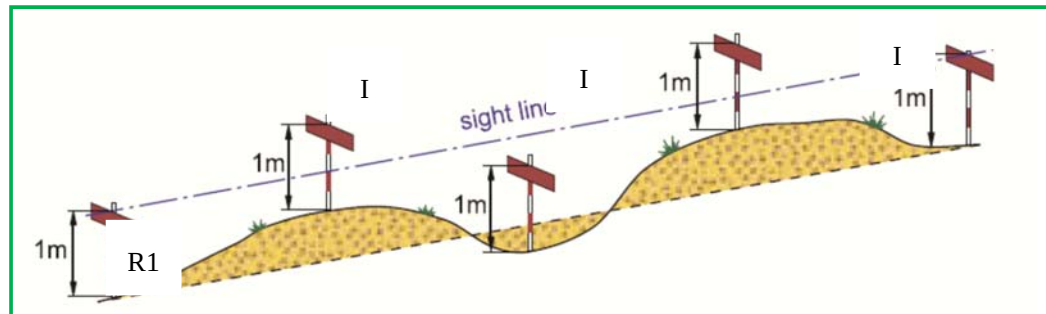


(ii) Set out gentle vertical curve by adjusting the vertical level

Once the horizontal road alignment has been established, the next step is to set out the vertical alignment, by fixing the level of the road at appropriate intervals along the centre line. To avoid the more earth cutting and fill it is importance to adjust the level of the road as bellow method:

Step 1

- Place the profile board at the reference points (R1, R2) and the intermediate points along the center line of the road. Fix the profile board 1 m above the ground level.



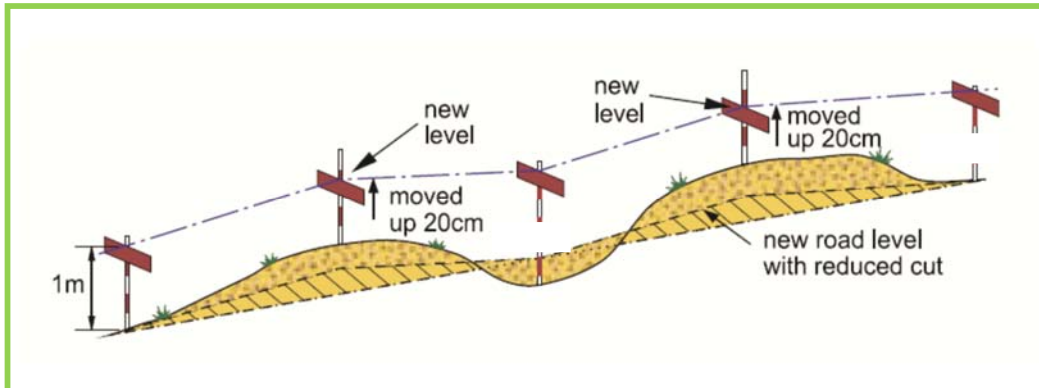
Step 2

- Sight along the profile boards from the 2 reference points (R1 and R2). Adjust the level of each of the intermediate profile boards (I) so they are all on line with the first and the last profile. All the profile boards will then be 1 m above the completed level of the road.

Step 3

- Where the level of the centre line cuts too deep into the terrain, this will involve excessive excavation work. The profile boards can then be adjusted up or down (as shown in the above figures) to reduce the earthworks and also achieving an improved balance between the volumes of excavation and fill. The profile can be adjusted by eye. Finally, make sure that the profile boards along the centre line

have been correctly placed. All other levels for the road structure will be set out based on the profiles along the centre line.

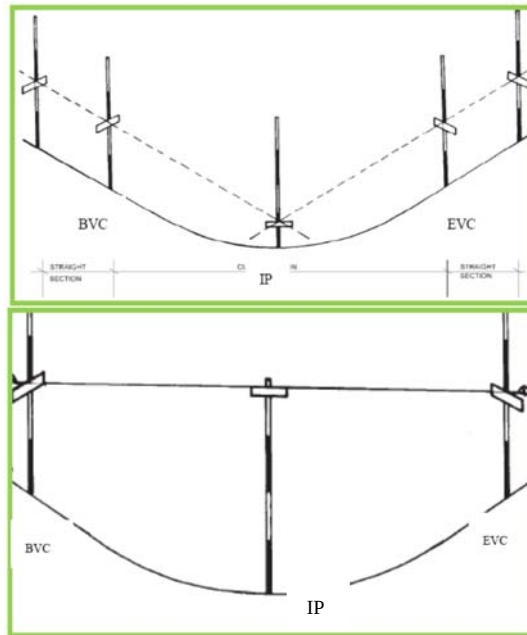


(iii) Set out sags

The sag is a vertical curve joining of two sections of straight grade to form a valley or dip. Obviously if we construct the road with a sharp dip at a bottom of sag, it will uncomfortable and dangerous for the road users. To set out the sag it is necessary to follow the steps below:

Step 1

- ✚ Place one profile board at the beginning of vertical (BVC) curve and one profile board 10 m before the beginning of curve and raise the two profile boards 1m above the ground level . Do the same at the end of vertical curve (EVC).
- ✚ Locate the intersection point (IP) which is the meeting points of the 2 straight grades of the BVC and the EVC. Mark the IP level

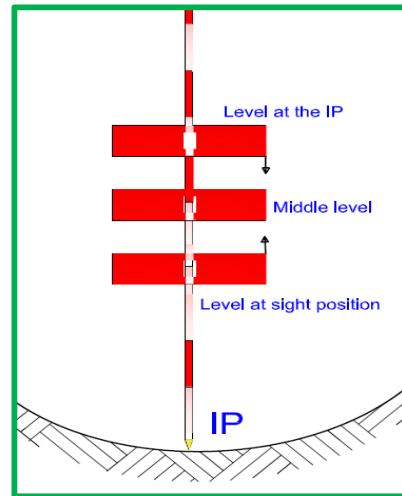


Step 2.

- ✚ Sight across these profile boards of the BVC and the EVC, and have an assistant mark the line of sight on the point of intersection profile board.
- ✚ Measure the height of this mark on the pole in the middle of the curve from the top of the profile. Halve the measurement and mark it on the profile pole.

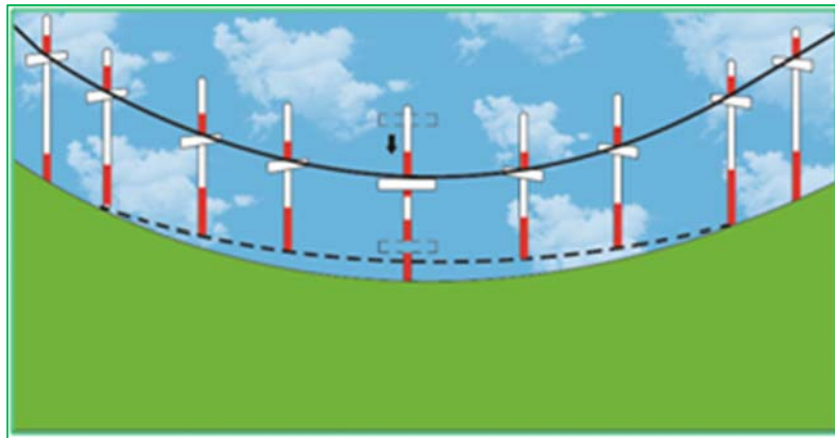
Step 3.

- ✚ Measure the distance between the two marks on the rod at **IP** and halve it. Measure out the halved distance from either of the marks to mark the midpoint of the two. Fix a profile board at this new mark.



Step 4.

- ✚ Get a piece of string about twice the length of the sag curve. Tie one end at the top of the profile board at BVC. Walk towards EVC draping the string over the profile boards on the intermediate profile board and definitely over the profile board on the at **IP**. Pull the string line tight until a sag curve is formed by the string due to its own weight. The sag profile formed by the string will have one end on top of the profile at BVC, the other end on top of the profile at EVC and the bottom of the sag on top of the profile at **IP**.



Step 5.

- ✚ Remove the string and, once again, check that the adjusted profiles form a smooth a curve. If not, make slight adjustment as appropriate. When the curve is acceptable, place new centre line pegs at each ranging rod with tops at 1m below the profile boards.

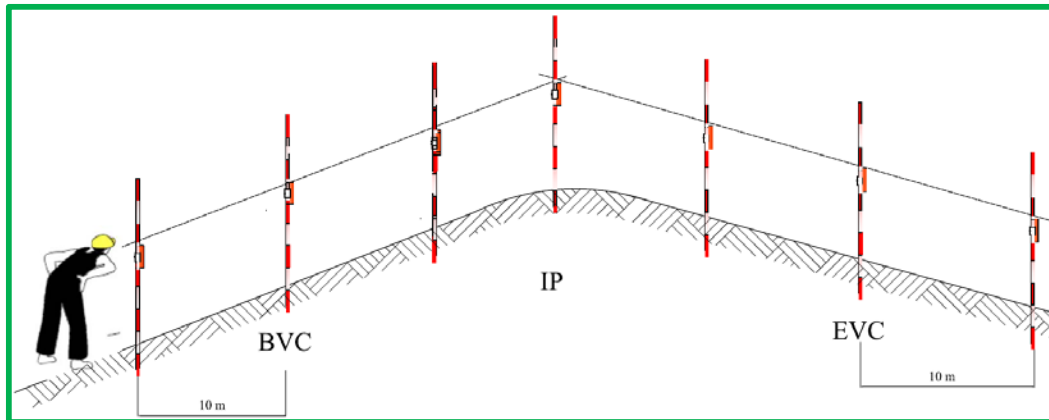
(iv) Set out crest

The crest is a vertical curve joining two sections of straight grade to form a crest. Obviously, if we construct a road with a sharp peak at the top of a crest it will not only be uncomfortable to drive over but very dangerous because road users will not be able to see oncoming traffic. Where is a sharp vertical curve it is to cut and smooth the curve which is called "crest". A crest curve can be set out using the profile in the same way as described for sag curves before. The steps to follow are

shown in the list below.

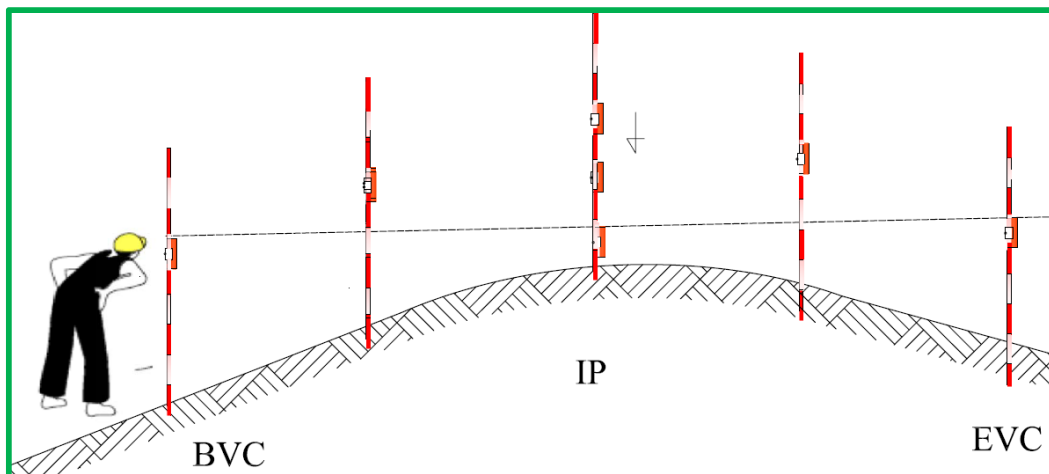
Step 1

- ✚ Set 1 profile board at the beginning of vertical (BVC) curve and 1 profile board 10 m before the beginning of curve and raise the two profile boards 1m above the ground level. Do the same at the end of vertical curve (EVC).
- ✚ Locate the intersection point (IP) is the meeting points of the 2 straight grades of the BVC and the EVC. Mark of the IP level



Step 2.

- ✚ Sight across these profile boards of the BVC and the EVC, and have an assistant mark the line of sight on the point of intersection profile board (IP).
- ✚ Measure the height of this mark on the pole in the middle of the curve from the top of the profile. Halve the measurement and mark it on the profile pole.

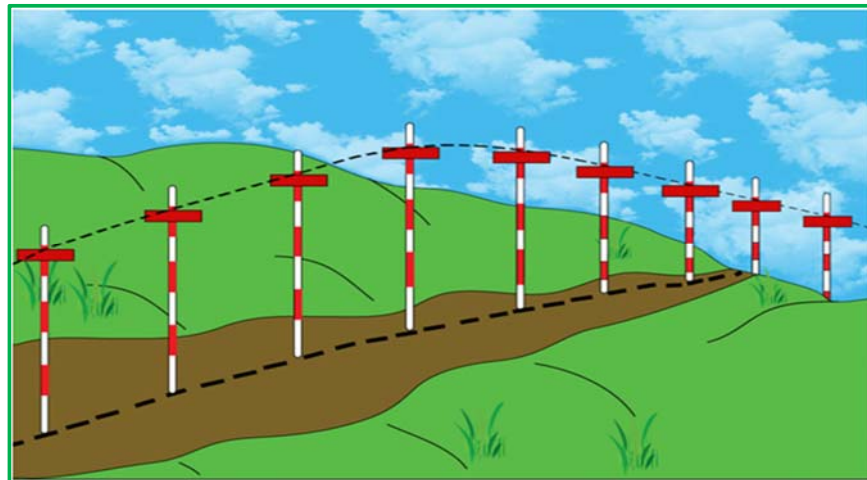
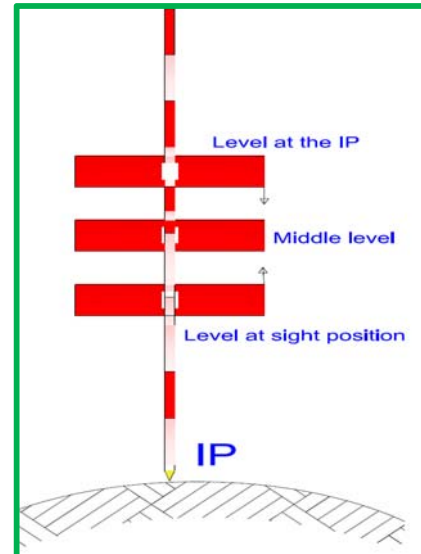


Step 3.

- ✚ Measure the distance between the two marks on the rod at **IP** and halve it. Measure out the halved distance from either of the marks to mark the midpoint of the two. Fix a profile board at this new mark.

Step 4.

- ✚ Adjust the remaining intermediate profile boards between the BVC and EVC by eyes. The remaining profile boards should make a smooth curve.
- ✚ Put a string above the profile boards to form a curve. Look again at the curve, check that the adjusted profiles form a smooth a curve. If not, make necessary slight adjustment as appropriate.



Step 5.

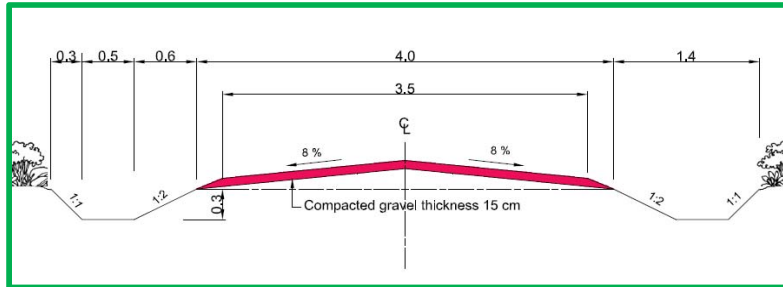
- ✚ Remove the string and, once again, check that the adjusted profiles form a smooth a curve. If not, make slight adjustment as appropriate. When the curve is acceptable, place new centre line pegs at each ranging rod with tops at 1m below the profile boards.

F-5 Setting out cross section

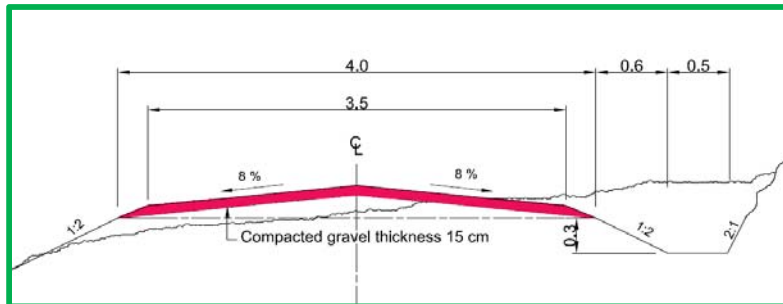
The cross section of a road to be set out should be selected according to the classification standard for the rural roads construction as described in this manual.

The cross section dimensions may be adjusted to local conditions according to the design of the engineer. However, in Timor-Leste, there are three standard road cross sections for rural roads as shown below:

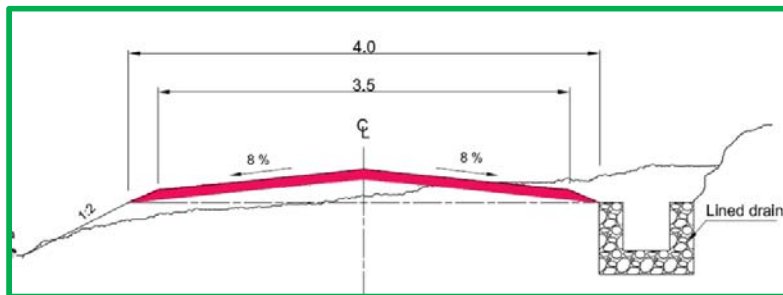
1. Cross section in rolling terrain. This type of the road cross section is mostly built with side drains on both sides.



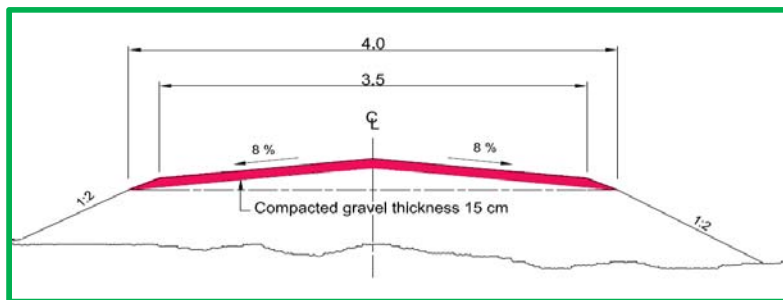
2. Cross section in mountainous terrain where the longitudinal gradient less than 10%. This typical of cross section has side drain at the inner slope and slop at the low side.



3. Cross section in mountainous terrain where the longitudinal gradient greater than 10%. This typical of cross section has side drain at the inner slope and slop at the low side.



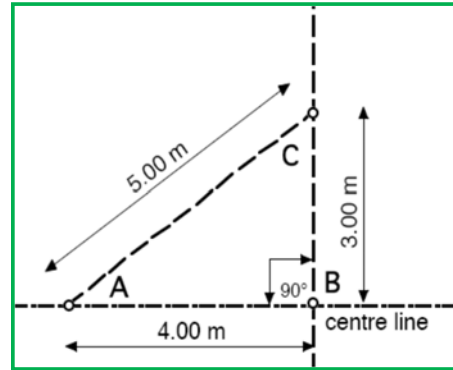
4. Cross section embankment. This type of road cross section is built in the flat terrain which may be flooded during the raining season.



Set out cross section

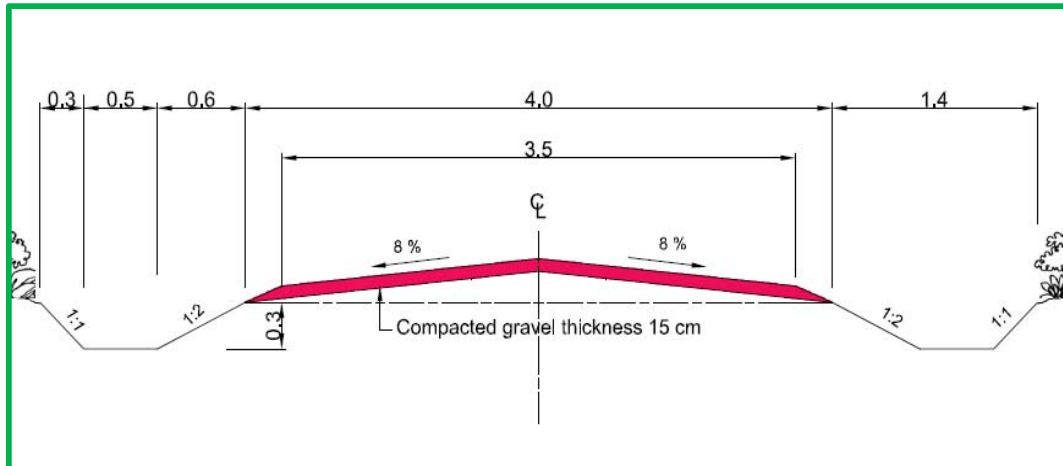
Normally,, sections of not more than 50 to 100 m are set out at the time in straight locations. If there are many curves in mountainous terrain, sections of less than 25 m may be chosen. The cross section pegs should be set out at a right angle to the centre line pegs.

All cross sections should be set out at right angles (90°) to the centre line of the road by using 3-4-5 methods.



- ✚ **Step 1:** Measure the length AB of 4 m along the center line of the road. Set pegs at the point A and B
- ✚ **Step 2:** Hold the zero point of the tape measure on the peg A. A second person holds the mark 8 m on the tape measure on peg B. A third person holds the tape measure on mark 5 m which will lead to point C when the tape measure is pulled tight. Set peg on point C
- ✚ **Step 3:** Hold the tape tight and the B point forms 90° with point C

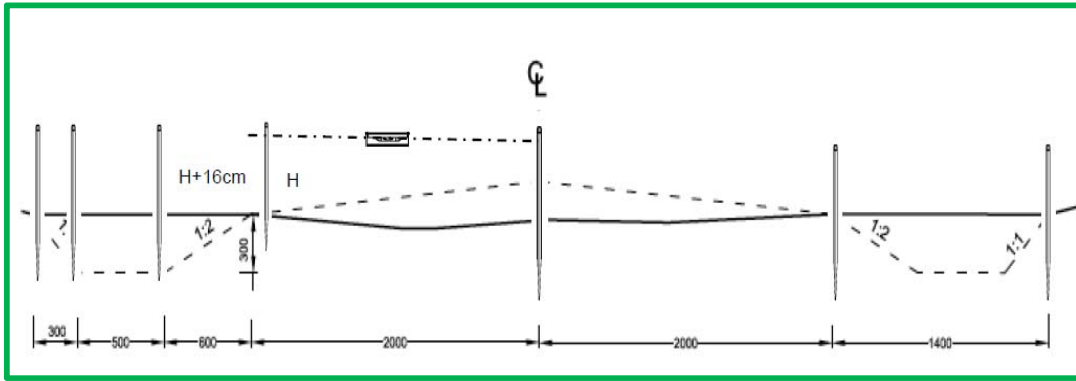
F-6 Set out cross section side drain and camber in rolling terrain



Follow the steps below to set out this type of cross section in rolling terrain:

Step 1:

- ✚ Establish 90° angle with the center line of the road as method described above.
- ✚ From the center measure half width of the road which is shoulder of the road and set peg at the shoulder break point.
- ✚ Set pegs for the side width of the side drains. 1 peg for at the toe slop and 1 peg at the bed of the side drain and 1 peg at the end of the back slope.



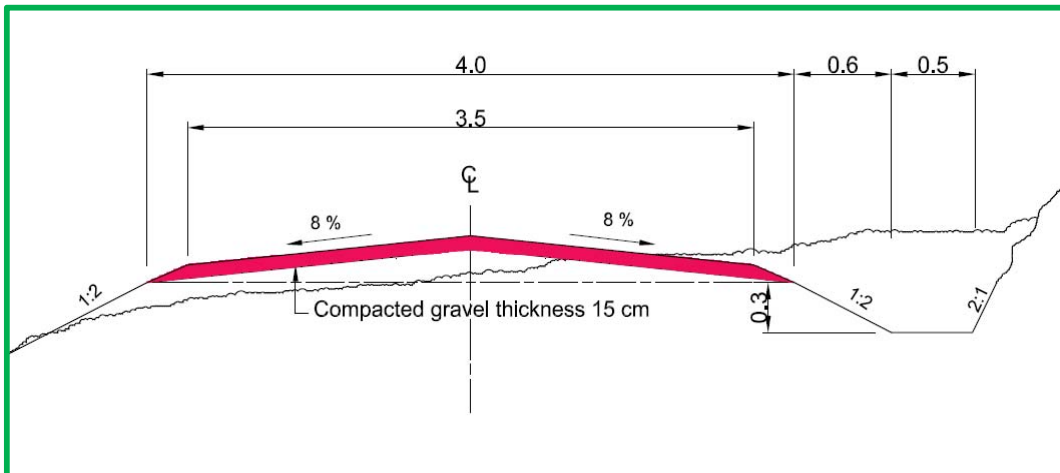
Step 2:

- ✚ Set level of the shoulder by transferring the level of the camber by line level. The cross fall for the camber should be 8%. Mark the shoulder level at the shoulder peg.
- ✚ Set depth of the side drain by using line level to transfer the camber level to the depth of the side drain and measure down 0.5 m below the camber level.

Step 3:

Repeat the same procedure to another site of the road so we will receive the cross section of the road

F-7 Set out cross section road in mountainous terrain.



Follow the steps below to set out this type of cross section in mountainous terrain should

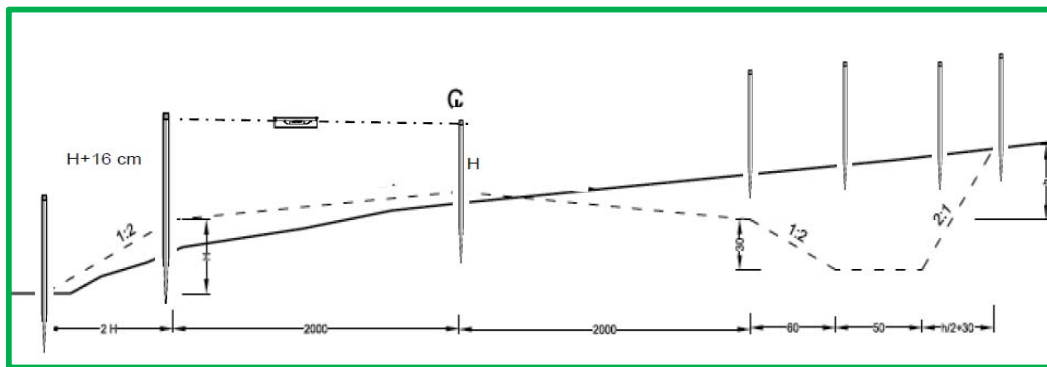
Step 1: set out at the low side

- ✚ Establish 90° angle with the center line of the road as method described above.
- ✚ From the center measure half width of the road which is shoulder of the road and set peg at the shoulder break point.

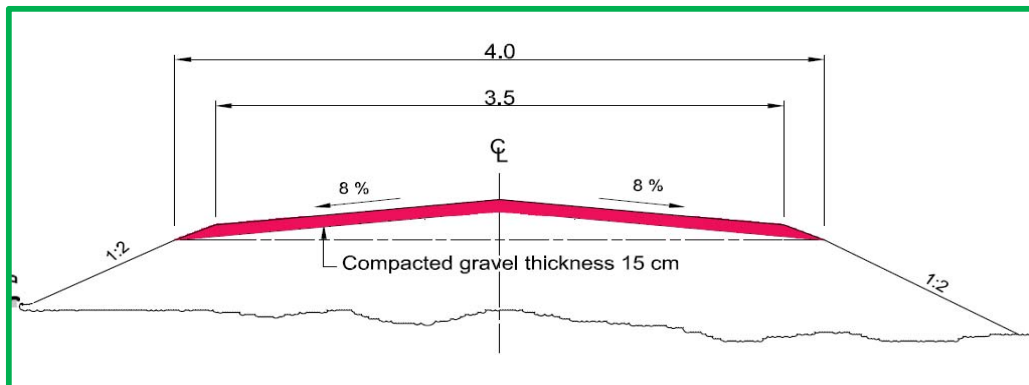
- ✚ Use line level transfer elevation from the center line to shoulder peg and mark at the low side.
- ✚ At the low side to measure the high (H) from the ground level to the shoulder level. Set a peg at the toe slop which the distance from the shoulder peg is $2 \times H$.

Step 2 set out at the high side

- ✚ At the high side to set peg of the side drain. Repeat the process of setting side drain as mentioned in the above (same as side drain setting out of the road in rolling terrain) procedure.
- ✚ Set level of the shoulder by transferring the level of the camber by line level. The cross fall for the camber should be 8%. Mark the shoulder level at the shoulder peg.
- ✚ Set depth of the side drain by transferring the camber level by using the line level. The depth of the side drain at the high side shall be 0.3 m below the shoulder's level.
- ✚ Set peg at the back slop by measuring the level (h) from the shoulder to the top of the back slop. The distance from the bed from the drain to the back slop is: $h/2 + 15\text{cm}$



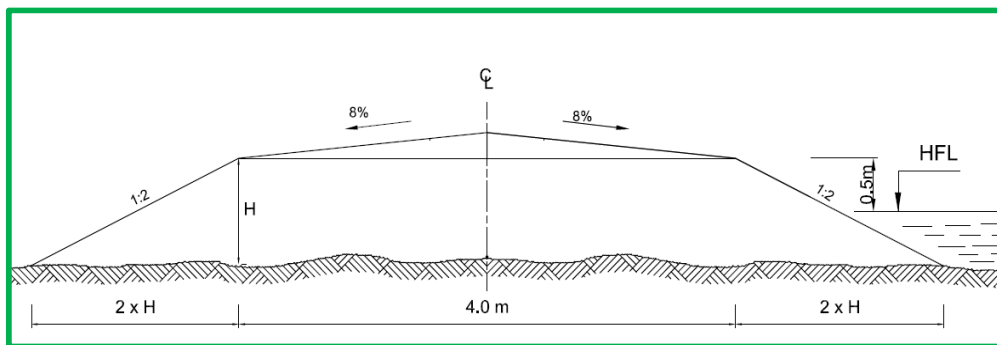
F-8 Set out cross section of embankment (road in flat terrain).



This type of road is normally built at the flat terrain or the location where is flooded. Follow the steps below to set out this type of cross section

Identify High Flood Level (HFL). Normally the HFL can be found from a tree electricity post or some other permanence structure near to the road section.

- ✚ Transfer the HFL to the road center line.
- ✚ Establish 90° angle with the center line of the road as method described above. From the center measure half width of the road which is shoulder of the road and set peg at the shoulder break point. From the level of the HFL measure up 0.5 m which is the level of the road shoulder.
- ✚ Measure high from the shoulder level to the ground level (H). Calculate the end point of the toes slops by measuring $2 \times H$ from the shoulder pegs.
- ✚ Set level of the camber by measuring up from the shoulder level of 8%.



LBT Training Manual

Module G

Earth Works

Table of Contents, Module G Earth Works

G	Earth works	3
G-1	Clearing.....	3
G-1-1	Bush clearing.....	4
G-1-2	Boulder removal	4
G-1-3	Grubbing and top soil removal	6
G-2	Construction of earth works	7
G-2-1	Leveling	7
G-2-2	Construction side drain and camber (road in rolling terrain).....	8
G-2-3	Cut and fill (road in hilly terrain).....	10
G-2-4	Construction of embankment.....	12
G-2-5	Compaction	13
G-2-6	Planting grass	14
G-3	Quality control for earth works construction and planting grass.....	14
G-4	Safety and health for earth works construction	16

G Earth works

The most common form of earthworks for road construction involves digging drains and using the material to build up the camber or excavating cuts and using these soils to form the road. In flat areas with poor drainages, earthworks involve building up the road embankments.

Earthworks is usually a very costly operation in road construction, sometimes, accounting for more than half of the construction cost.

The principle activities are:

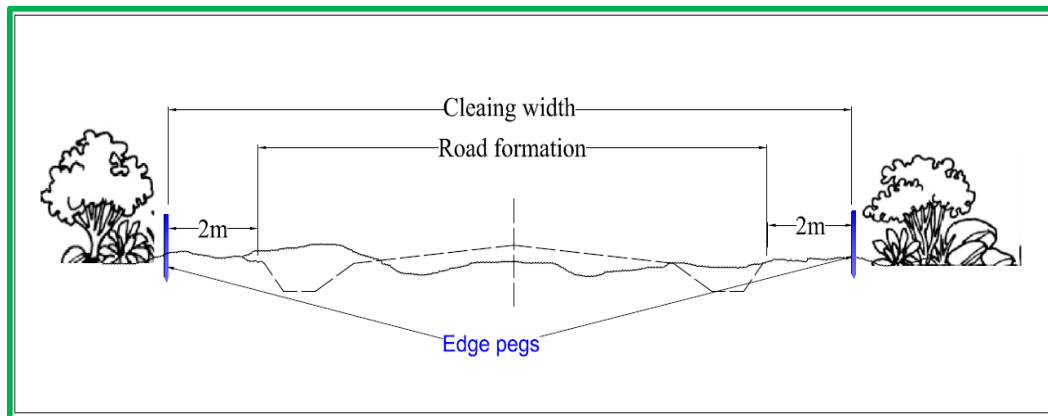
- ✚ measuring and calculation of volumes,
- ✚ excavation which includes leveling, cut to cross-fill, U-cut and borrow excavation,
- ✚ loading, hauling and unloading,
- ✚ filling, including spreading, watering and compaction.

Earthworks is very suitable operation for using the incentive schemes like task work because the volume of work can be easily measured.

Suitable "tasks" can be determined after the basic soil properties, e.g. hardness and cohesiveness, have been defined and productivities established.

G-1 Clearing

Site clearing is normally the first operation to be done when the alignment has been set out. It is done in order to prepare the site for the excavation and formation of the road. It consists of the removal and disposal of all bushes, trees, fences and loose boulders as well as the grass within the topsoil.



Clearing is normally done to the road formation width plus 2 m on each side. When the road is set out, it is important that the alignment is chosen so that the damage to the surrounding is minimized. This means that in some cases, it is better to take the road around a group of trees or a small hill instead of going straight through it. The clearing operation involves in several activities as described below.

G-1-1 Bush clearing

Bush and grass clearing is the cutting, clearing grass and removal of all bushes, shrubs and grass within the clearing width and disposing of the cuttings outside the clearing width.

Work method

- ✚ Setting out clearing width using pegs and string line to set the area to be cleared. The clearing width should not be less than 2 m outside road formation
- ✚ Calculate quantity of work to be done for one day and calculate number of labourers to carry out the work accordingly.
- ✚ The clearing work should include removal of all grass and bush from the clearing width
- ✚ The removed material should be discarded outside of the clearing width. Burning of the material should be done outside the clearing width and must be approved by the engineer in charge.



G-1-2 Boulder removal

Boulder removal activity involves the removal of large stones or boulders from within the clearing width of the road their disposal at suitable and approved locations.

Work method

There are various methods that can be employed to carry out this activity. They may be used separately or in combination. The method to be used shall depend on the size, shape and position of the boulder and on which tools and equipment are available.



However, irrespective of the method used, rock must be disposed of at appropriate locations outside the cleared width. Some of the stones may be used for scour checks and other masonry structures.

Moving the boulders out of the cleared width: Boulders may be carried, rolled, towed or pushed in the following ways:

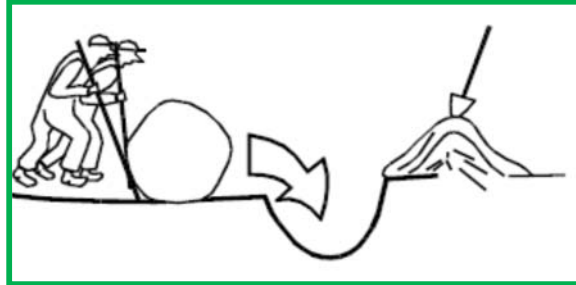
If the boulders are small the simple following method can be applied:

- ✚ physical lifting of boulders by workers and dumping them outside the clearing width,
- ✚ workers rolling boulders outside the clearing width with the aid of crow bars,
- ✚ workers towing boulders outside the clearing width with the aid of ropes

If the boulders are big that cannot be applied the above methods, the following methods can be applied:

Burying boulders below the sub grade level

First dig a hole near the boulder with same or a bit bigger than the boulder and the depth must be more than the height of the boulder. Push the boulder into the hole using crowbars, it may be necessary to use jacks and/or stones to prop up the boulder to allow the crowbars to shift



positions. If boulders are too big or too deeply embedded to dig them out, it may be necessary to simply raise the road level such that the boulders are at least 0.2m below the sub grade level.

Splitting boulders using fire and water

If the boulders are too big to apply the above methods it is necessary to split the boulders using the fire and water method. First fire the boulders around and over it to heat it of about at least 6 hours to heat up and expand the rock sufficiently. This heating stage can also be done overnight to save on time. The boulder should then be cooled rapidly by dousing it with large volumes of water. The rapid cooling will cause



shrinkage and cracking of the rock. Cracking may also be encouraged by striking the boulder with sledgehammers at this stage. The rock can then be split into pieces using chisels and sledgehammers along the cracks. Depending on the size and type of rock, the process of heating, cooling and cracking may have to be repeated a number of times before the resultant pieces are manageable.

Blasting boulders with explosives

If there is a large boulder or a solid rock face to be removed, then the use of explosives may be justified. Care must be taken in drilling holes for the explosives (using hand tools or compressed air driven tools) in the correct location and orientation. Handling of explosives and blasting must be carried out by a licensed blaster. The blaster will also advise on the location and orientation of the holes for the explosives.

G-1-3 Grubbing and top soil removal

This activity follows immediately after bush and grass clearing. It is to remove all vegetation, roots, stumps, unsuitable and organic material and outside the road formation width. The activity is normally done over the width that earthworks will take place.

Work method

-  Setting out pegs and string line for the width of road formation to be cleared for interval every 10m
-  Calculate quantity of work and space for each worker to work to ensure safety. The width the grubbing should be the width of road formation.
-  Removal all the roots, stumps, unsuitable material, vegetation. Where the topsoil is to be removed is usually only needed where the weak topsoil is deep (10-15cm) that consists of organic material. Topsoil removal is most likely to be needed in river valleys and flood areas that build up silt. Most agricultural land and open areas are eroded, with a very thin topsoil layer, which can be mixed in with the earthworks for the road construction.
-  All the wasted material from the above activity shall be loaded in wheelbarrow for disposing unless the disposal area is within the shovel throwing distance.

Safety During Clearing Operation

During clearing works, attention should be paid to safety as follows:

Tree cutting	When using the rope for tree felling, ensure that the length of the rope is longer than the height of the tree. This will allow the gang pulling the rope to be well clear of the tree as it falls. Tree felling should not be attempted when there is strong wind. All workers shall be equipped with helmet and gloves.
Removal of boulders	- When splitting rocks using hand tools, labourers must wear boots eye protection glasses and gloves to protect against bruising. - For blasting, only specially trained and licensed people can be allowed to take charge of the activity. These trained people will be able to implement all the necessary safety procedures. - When boulders are to be buried, care must be taken so that the boulder does not roll into the pit while workers are still digging or working inside the pit.
bush and grass clearing	- Workers must be well spaced (especially when working in gangs) to limit the risk of injury when using cutting tools. - Where burning of debris is necessary, care must be taken to prevent fire spreading outside the cleared width. Water and/or sand must be readily available at the site when burning is to be carried out.

G-2 Construction of earth works

G-2-1 Leveling

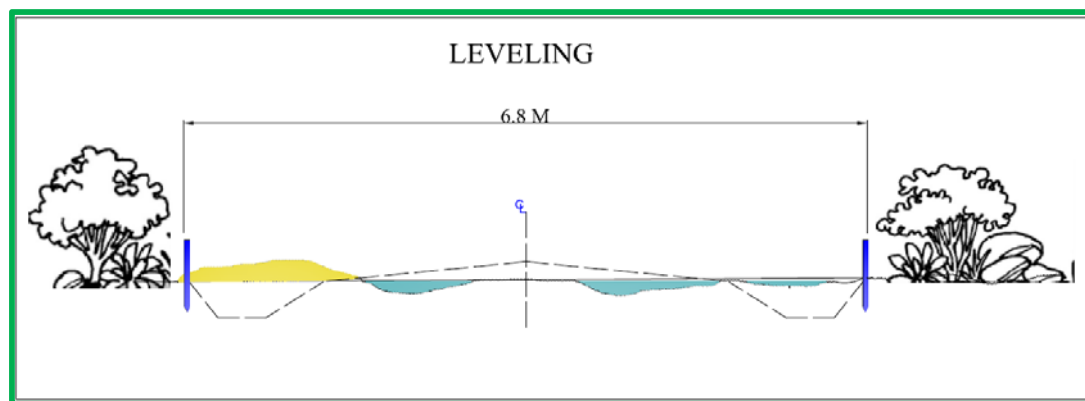
Excavation to level is carried out to provide a level road width, in accordance with the designed vertical alignment, on which the drainage and camber can be constructed in an accurate and controlled manner. The leveled width is the distance from one outer end of the ditch invert to the outer end of the ditch invert on the other side of the centre line.



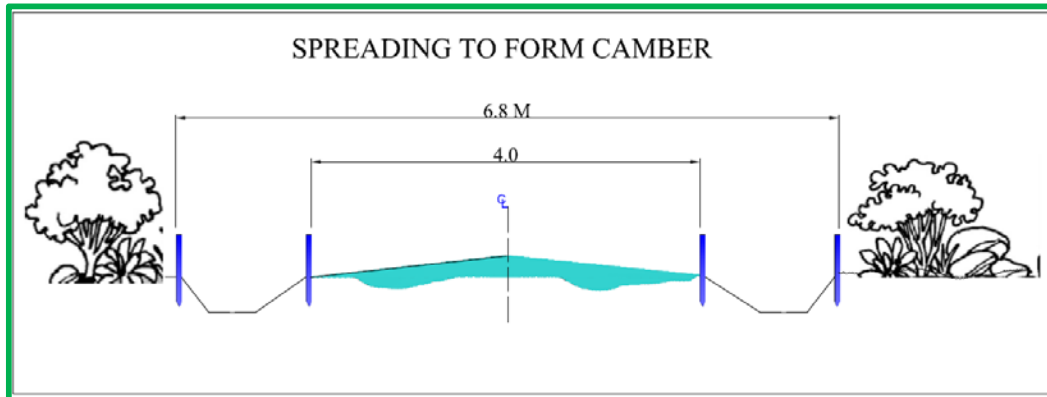
The leveling operation shall be done before commencing the ditching and cambering operation.

Work method

- ✚ set out pegs for every 10 m at the road way and tie string line between the pegs.
- ✚ Excavate the high level to fill the low level within the set pegs and string line and throw excess material to the low side
- ✚ Spread the filled material to make level than provide water to optimum moisture content and compact using a roller.

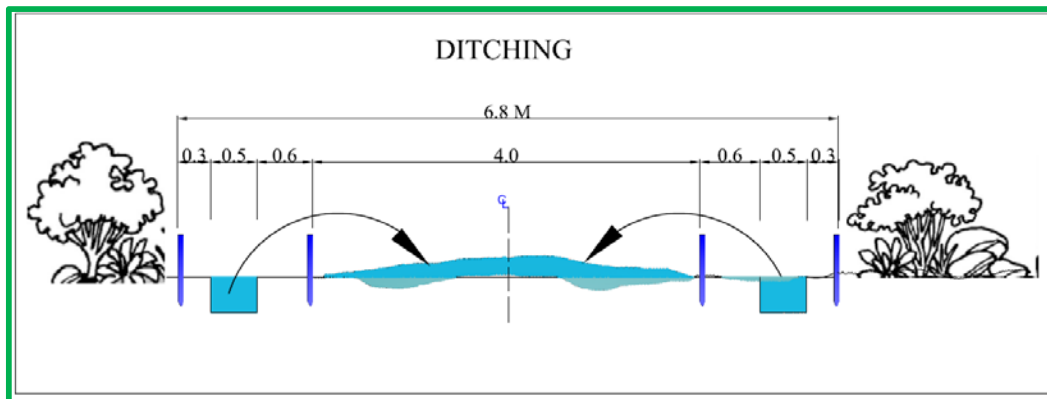


G-2-2 Construction side drain and camber (road in rolling terrain)



When rehabilitating an existing road, leveling works should be kept to a minimum, leaving the existing road camber in place and only adding onto it where it has been worn down.

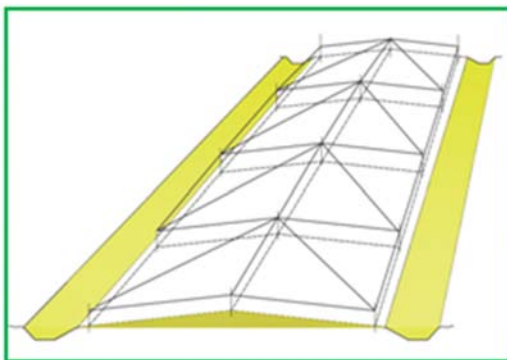
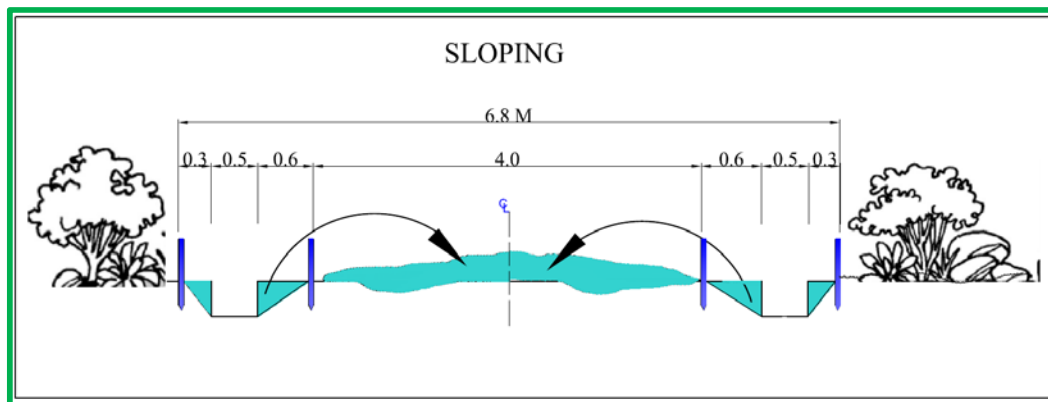
Volumes to be excavated can be calculated in advance for the most common profile heights. The road camber is set out together with the side drains. Once the position and level of the centre line has been determined, it is possible to construct the side drains and camber. The following steps shows the side drains and the camber can be constructed together.



Step 1: Excavate the side drains in a rectangular shape on both sides as shown in the figure. The excavated soil from the side drains should first be thrown to the centre of the road, from where it is leveled out towards each road shoulder to form the camber.



Step 2: Cut front slopes of the side drains. The excavated soil should be thrown again onto the road carriage way. Thereafter excavate the back slopes of the side drains. Once the side drain excavation and fill have been completed, spreading to form road camber should then commence.



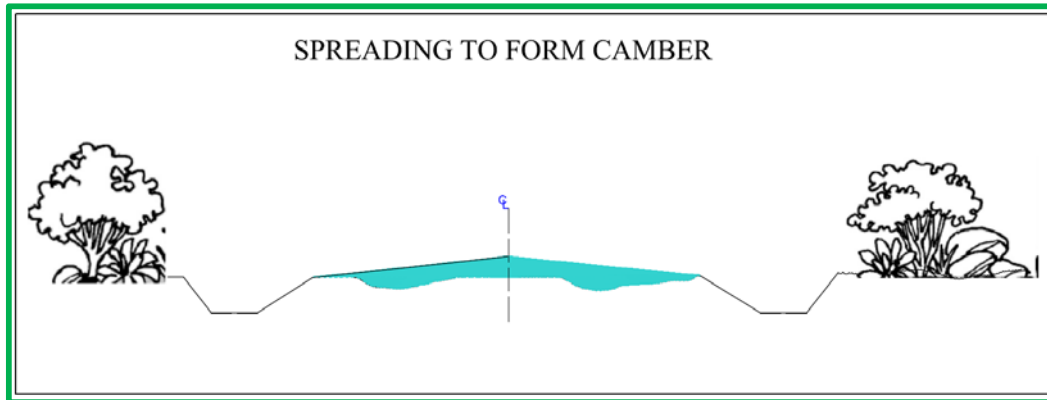
Step 3:

The camber is formed by spreading the material excavated from the drains. The material is spread evenly from the centre line out towards the shoulder break points. The camber should be about 10% before compaction and 8% or as required by the Engineer after compaction. Use a camber board and a spirit level to check the final camber or use the line level to check the camber. Once the soils for the camber has been

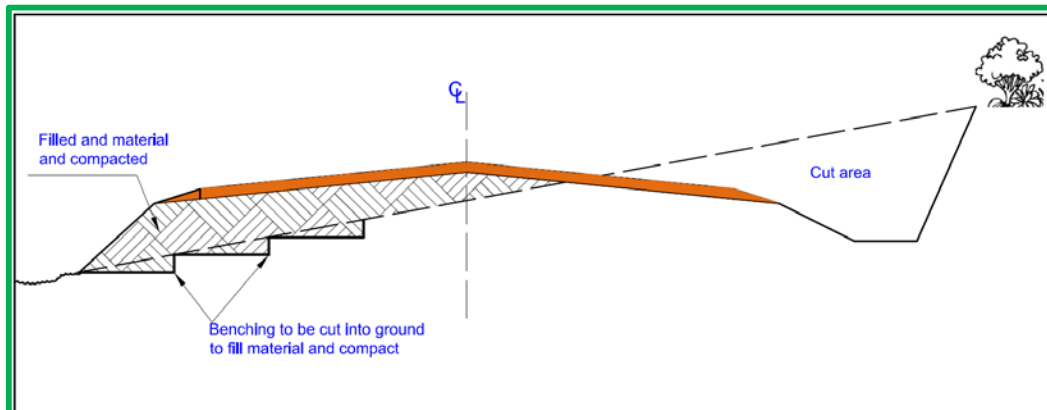


spread compaction should commence. Make sure that the soil contains optimal moisture content during compaction.

A few workers should be assigned to work with the roller to fill the low spots that might appear during the compaction. It is also important to keep the camber intact during the compaction.

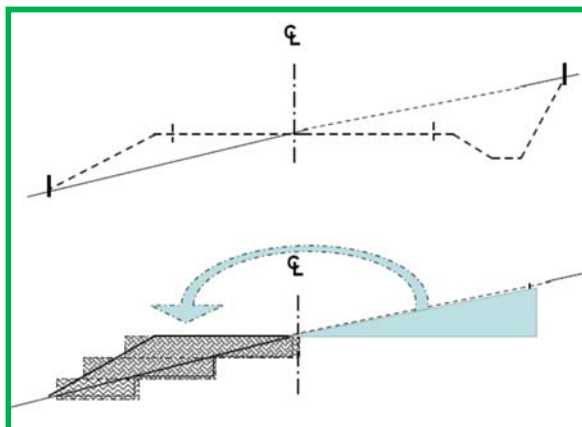


G-2-3 Cut and fill (road in hilly terrain)



This type of road is built mainly in a hilly terrain where it is necessary to cut the hill on high side to fill the low side. The following steps should be followed when constructing roads in hilly terrain:

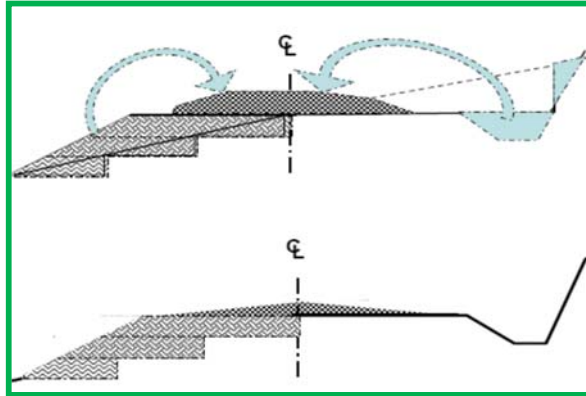
Step 1: cut benching (steps) at the low side. Width of the step should not be less than width of a roller and height of the step should not be greater than 15 cm to allow proper compaction.



Step 2: cut the high side. The soil from the cut is used to fill the step at the low side. Before commencing filling of the second step, the first layer (step) shall be compacted. Continue filling the benching (steps) until reaching level of the road shoulder.

Step 3: construct side drain at the high side. Throw soil from the side drain to the middle between the two shoulder pegs. Then cut slope of the low side, soil from the cut to throw to the middle of the road.

Step 4: spread to the soil from the side drain and from the slope to form road camber. Level of the spread soil should not be higher than the set string line. The camber should be about 10% before compaction and 8% or as required by the Engineer after compaction. Use a camber board and a spirit level to check the final camber or use the line level to check the camber. Once the soil for the camber has been spread compaction should be commenced. Make sure that the soil contains optimum moisture content during compaction.



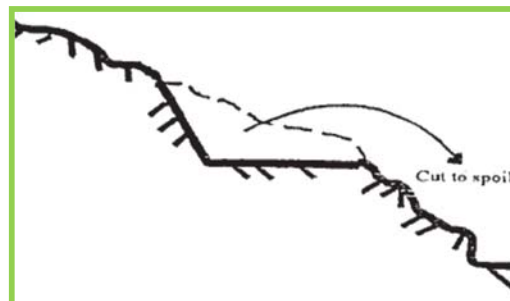
Excavation procedures

This figure shows most effective sequence for excavating to level. Excavation should start first with the top triangular part and then continue with the triangle of the bottom part. Lastly the rectangular part shall be excavated.

To guide the workers, multipurpose pegs can be set at the exact place where excavation has to start. To further guide the workers, these pegs are then connected with strings. If the work is to be undertaken by a group of workers (group task), it must also be set out to define the limits of the quantity (number of worker x task rate).

Cut to spoil

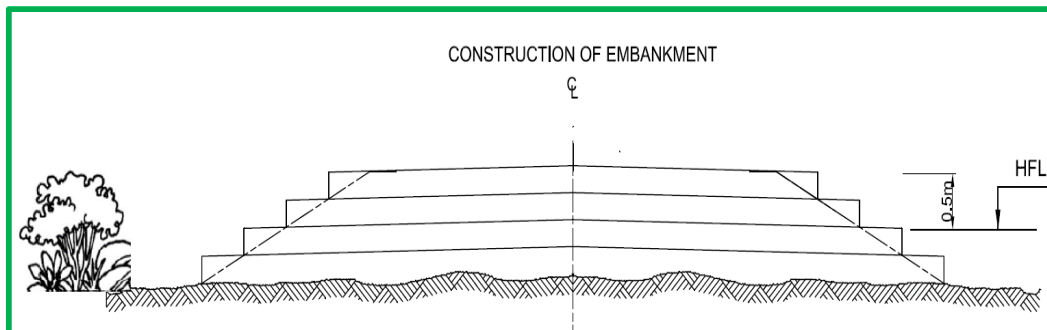
Where the cut material is exceeding the required filling, the remaining material shall be thrown out of the roadway. This should be applied when the side long slope is too steep and cannot safely support the fill material and/or cannot safely allow workers to work on it. For this situation, the task rates can be increased a bit as spreading and compaction is not needed.



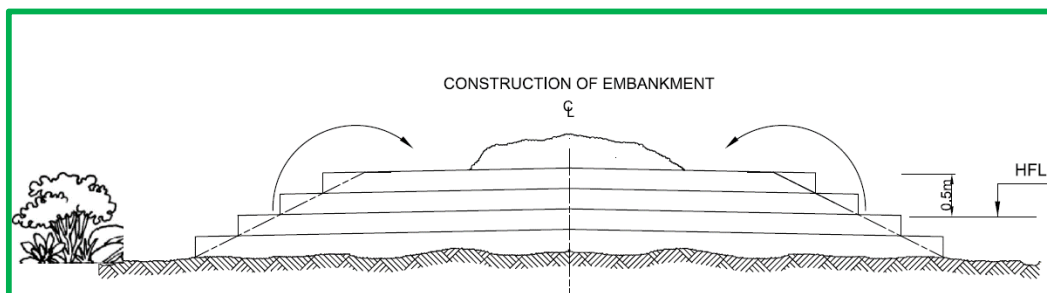
G-2-4 Construction of embankment

A road on embankment is built in locations which are likely to be flooded, eg as a road crosses rice fields or swamps etc. The embankment should be raised to a level above the High Flood Level (HFL). To construct the embankment the steps below should be followed:

Step 1: Identify the HFL and transfer the level to the road center line. The HFL can be seen on a tree, electricity post or any permanent structure which were flooded during flood season. Minimum level of the road shoulder should be set 0.5m above HFL. The embankment should be filled in layers of less than 0.2 m to enable proper compaction before the next layer can be placed. Continue the layers and compact each layer to the level of the road shoulder.

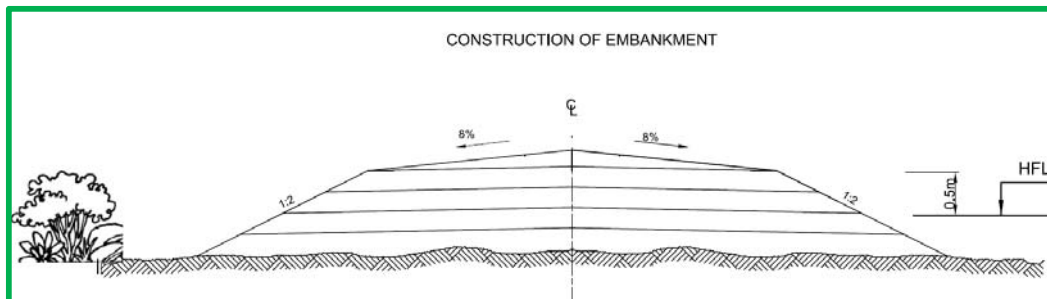


Step 2: Once the layers have reached to the level of the road shoulder, sloping activity can commence. Soil from the cutting of slopes shall be used to fill and form road camber.



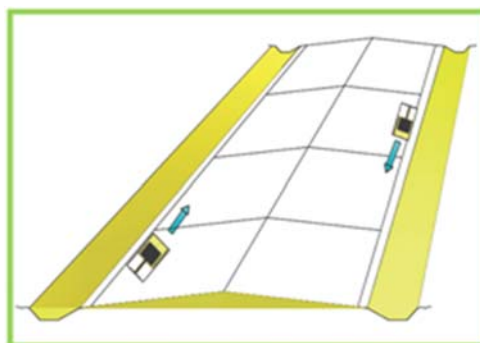
Step 3: Soil from the cutting of slopes should be spread carefully following the string line which has been set out. The level of the spread soil should not be higher than the set string line. The material is spread evenly from the centre line out towards the shoulder break points. The camber should be about 10% before compaction and 8% or as required by the Engineer after compaction. Use a camber board and a spirit

level to check the final camber or use the line level to check the camber. Once the soils for the camber has been spread compaction should commence. Make sure that the soil contains optimum moisture content during compaction



G-2-5 Compaction

To produce a good quality road, it is important that all soils are properly compacted. Compaction should be carried out along the road line starting at the shoulders of the road and gradually working towards the centre line.



To gain even compaction, assign and train specific workers to operate the compaction equipment. They will become experienced at running the rollers at a constant speed for good compaction and will also maintain the rollers.

Make sure that the camber of the road is always maintained at 8% (after compaction) for both the base layers as well as the gravel layer.

After compaction has been completed, it is important to check that the final levels of the road camber is exact and to the prescribed standard and quality.

Compaction procedure and Quality Control are described in Module I paragraph I-9

G-2-6 Planting grass

Newly formed embankment slopes can easily be damaged (by run-off surface water, livestock etc). It is therefore advisable to protect the slopes as soon as they have been formed.

The protection can be done in different ways, a very effective but expensive way is to use stones for protection, however the most common and less expensive is to plant grass or other types of deep rooting vegetation on the slopes. Grass can provide very effective protection against erosion if the right method of planting and the right type of grass is used.

Grass planting should be done covering the slopes. Covering 100% of the surface with grass turfs gives a more immediate and more effective protection, but is more costly and time consuming to carry out. The grass can be collected during the grubbing activity or from the vicinity of the road. For easy handling, the grass turfs should be approximately 20 x 20cm. Care must be taken when cutting the grass so that the roots are not damaged. Grass also needs to be kept damp and away from the sun when stored. Before placing the grass, the surface should be watered if it is dry.



The newly planted grass needs to be protected from cattle and other livestock with a barrier of thorny bushes, twigs, branches, etc. Newly planted grass also needs regular watering.

G-3 Quality control for earth works construction and planting grass

Earthworks activities for road works include: (i) site clearing (ii) levelling (iii) side drain excavation, miter drain and catch water drain excavation (iv) camber formation and (v) grass planting. Quality control and tests for these works include simple checking and accuracy of dimensions and road profile, and compaction tests where applicable. The quality control shall be carried out on a daily basis by contractor's field staff and the Client assigned field staff.

Work activity	Test/check method	When	Tools
Site clearing	✓ visual inspection, check that the correct width of road to be cleared has been set out ✓ ensure pegs and string line are used for every 10m interval	Before starting the clearing activity	Measuring tape
	✓ visual inspection, check that clearing width is completely free of boulders, root, stumps, vegetation, organic material. ✓ The debris from this activity should be dumped and spread at locations where it will	After completion and before commencing levelling activity	

	not be washed back into the road reserve during the rains.		
Levelling	✓ visual inspection, check that correct width of road has been set out ✓ ensure pegs and string line are used for every 10m interval ✓ Check quality of materials used. It should be as specified or better quality material i.e. the soil should be free from vegetation or top soil. ✓ visual check that each layer of fill is not more 15cm ✓ randomly counting the number of passes made by roller during compaction.	During levelling activity	Measuring tape
	✓ visual inspection, check that the filled layer is sufficiently levelled ✓ perform compaction test (DCP or sand placement test) for every 100 m. accepted CBR > 10 %	After completion of the levelling and before commencing camber formation	
Side drain	✓ ensure pegs and string line are used for every max. 10m interval. ✓ Check the ditch dimensions (width and depth) as per the design ✓ Material from the side drain must be checked before used to form road camber. Soil must not contain organic material or vegetation. Top soil must not be use to form the rod camber. ✓ bad material to spoil, MUST be thrown away from road formation ✓ Check that material is placed at the centre third of the formation width.	During ditching activity	Template and measuring tape
	✓ visual inspection, check and confirm that the size and shape the side drain corresponds to the design for this location. ✓ check that gradient of the side drain has the correct slope, and can lead water to the lowest point. ✓ rectify if the shape and/or gradient is not properly done	After completion of the activity	
Mitre drain and catch water drain	✓ ensure pegs and string line are used for every 10m. ✓ check the width and depth of the ditch ✓ material from the excavation throw to block-off place	During ditching activity	Template and measuring tape and line level
	✓ visual inspection, check and confirm that the size and shape of the drain corresponds to the design for this location ✓ gradient of the drain can lead water to low place. ✓ rectify if the shape and gradient are not proper done	After completion of the activity	
Filling embankm	✓ check dimensions (bottom width and height of the embankment). The levels should be strictly controlled for each fill layer.	Before the start of graveling activity	Profiled boards, line

ent	✓ Check that the material is spread uniformly to specified width ✓ check each filled layer shall not more 15cm and compaction in layer. ✓ randomly counting the number of passes made by roller during compaction.		level, measuring tapes 30m and 5 m, DCP
Camber formation	✓ visual inspection, check for every cross section the width of the road and elevation of center line and shoulder pegs. ✓ ensure pegs and string line are used for every cross section (every 10m interval) ✓ Check that material is placed at the centre third of the formation width. ✓ Check that the material is spread uniformly to specified width and forms a cross fall from the centreline to the edge of both sides of the road (camber) by the specified percentage ✓ visual check each filled layer not more 15cm ✓ randomly counting the number of passes made by roller during compaction. ✓ compaction of each filled layer shall not more 15cm	During camber formation	Measuring tape, Line level or camber board, DCP or sand placement equipment
	✓ a visual check of finished level should be evenness and no soft spot appear on surface ✓ check levels of the camber must be checked at least every 20m along the road by using camber board and line level . ✓ perform compaction test (DCP or sand placement test) for every 50 m. accepted CBR > 10 %	After completion and before commencing graveling surface layer	
Planting grass	✓ Before planting the grass make sure the slope has been cut evenly according to the design and drawing ✓ During grass planting, make sure the grass coverage is per instructions and that the roots of the grass have been buried and compacted well. No roots to appear above the ground. ✓ After the grass planting, inspect that the grass has been planted from the road shoulder level to the toe of the slope at the bottom level.	After completion of surfacing activity	Measuring tape

G-4 Safety and health for earth works construction

This includes the provision of general safety and health measures for labourers on site for the construction of earth works and clearing activities.

G-4-1 Safety Measures

- ✚ Carry out a safety briefing for all workers before works begin. Make sure work is organized so that each worker has enough space to carry out his or her task without endangering to workers.

- ✚ Place warning signs or cones at each end of the work area. The warning signs should be placed 50-100 m away from the working areas. The text on the warning signs should read: "KUIDADU" or " HALAI NENEIK"
- ✚ All equipment operators must be trained in the use of their equipment (trucks, rollers, etc).
- ✚ Deep excavations for borrow pits shall be made safe by ensuring a sufficient angle of the slope so that they do not fall onto workers in the excavation.
- ✚ No children are allowed enter in the work area.
- ✚ The contractor shall not allow the use of alcohol or drugs on the works site or in the site camp.

G-4-2 Drinking water:

Drinking water must be available within 50 metres of all work sites approximately 2 litres should be available per worker per day

G-4-3 Safety Gear:

The workers shall be provided appropriate safety gear in sufficient numbers. All workers must be instructed how and when to use safety gear and items shall replaced when unusable or lost: The safety gear as listed below.

- ✚ Safety jackets in bright colours for supervisors and for all workers if working on a road that has frequent traffic
- ✚ Closed shoes and gloves for all workers for general road works. Note that cotton gloves need to be replaced regularly
- ✚ Gum boots and good quality gloves when working with sharp tools (e.g. pick axes), Carrying heavy loads and working in muddy places
- ✚ Hard hats for workers working in danger deep borrow pit or under a tree etc.
- ✚ Dust masks when working with activities that produces lot of dust or bad smell. Note that dust masks must be replaced regularly
- ✚ Safety goggles must be used when breaking rock or crushing stone or anytime there is a risk for eye injury

G-4-4 First Aid:

A first aid box must be provided on site and must be regularly checked and restocked.

LBT Training Manual

Module H

Drainage

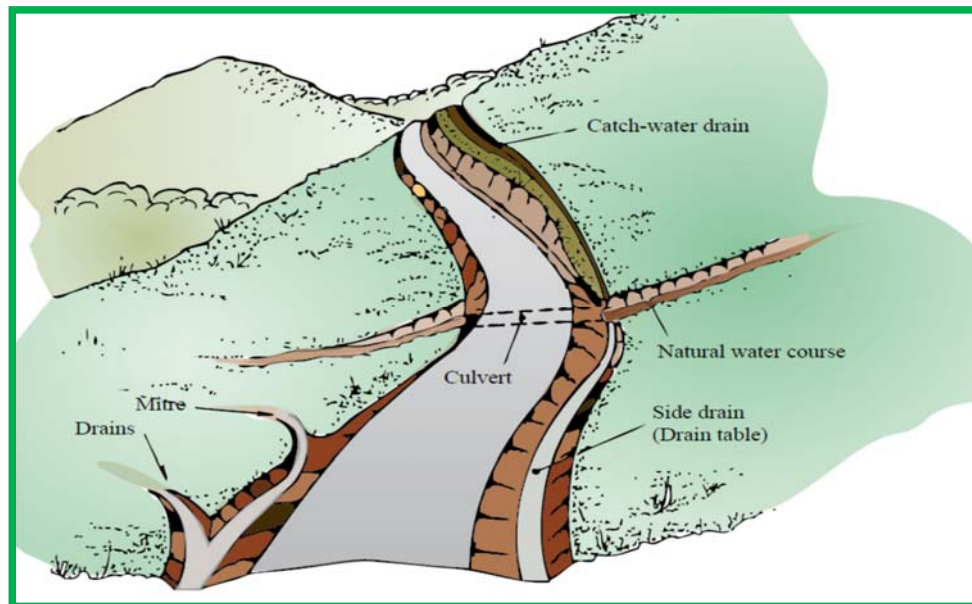
Table of Contents, Module H Drainage

H	Drainage	3
H-1	Catch water drains	4
H-2	Scour checks	5
H-3	Mitre drains	7
H-4	Surface drains	9
H-5	Cross drainage structures.....	10

H Drainage

Water is the main enemy of road! Water can be in the form of ground water, surface water (streams and rivers) or rain and it can damage the road. Roads can be impassible because of poor drainage system, which fails to lead water away from the road. An efficient drainage system is therefore essential to allow water to flow off and away from the road as quickly as possible. Drainage system of the road consisting of the following:

- ✚ **Side drains:** The side drains run along the road and collect the water from the carriageway and adjoining land and transport it to a convenient point of disposal.
- ✚ **Road surface drainage (camber):** which enables the water to flow off the road surface.
- ✚ **Miter drains:** Miter drains (or turn out drains) lead the water out of the side drains and safely disperse it on adjoining land. Miter drains should be provided as often as possible so that to reduce the accumulated water volume in the side drains to avoid erosion to the drain and adjoining land.
- ✚ **Catch water drains:** Where the road is situated on a hill side a significant amount of rain water may flow down the hill towards the road. This may cause damage to the cut face (back slope) of the road and even cause land slide. Catch water drains catch or intercept surface water flowing towards the road from adjacent land, and lead it away.
- ✚ **Scour checks:** Scour checks prevent erosion in side drains on steep gradients by slowing down the water (steps). Scour checks are usually built using locally available material, such as wooden sticks or stones.



- ✚ **Cross drainage structures:** The cross drainage structures are transverse drains built under the road and its function is to lead water from the upper or uphill

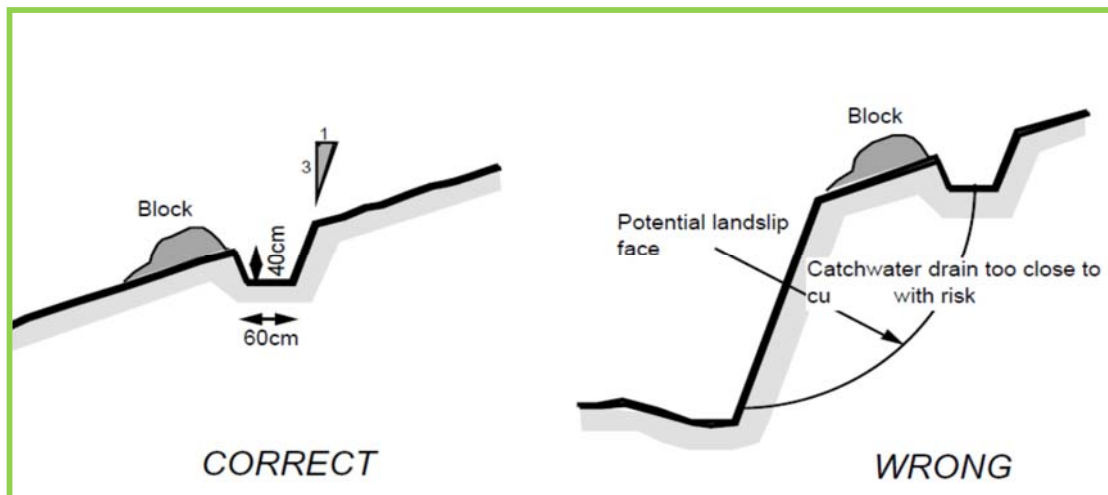
side of the lower or valley side of the road. In tropical countries with high rainfalls three to four culverts are required per kilometer.

H-1 Catch water drains

Where the road is situated on a hill side a significant amount of rain water may flow down the hill towards the road. This may cause damage to the cut face (back slope) of the road and even cause land slide. Catch water drains catch or intercept surface water flowing towards the road from adjacent land, and lead it away.

The catch water drain will often need to be sited on the adjacent owner's land and their cooperation will be required. The catch water drain should be carefully located so that:

- ✚ it drains at a satisfactory gradient through its length,
- ✚ it is not so close to the cut face that it increases the danger of a land slip.



Construction of catch water drains: When constructing the catch water drain the steps below should be followed:

Step 1 Set out the catch water drain using pegs and string lines. Ensure the gradient of the catch water drain is between 2-4%. The drain should not be too close to the cut face of the slope. It is recommended that the drain should be 60 cm wide and 40 cm deep. The slope of the drain should be 3:1 or 2:1 as shown in the above figures.

Step 2 Calculate volume of the excavation works per day and allocate workers accordingly.

Step 3. Excavate the drain. Material from the excavation should be heaped at the low side of the hill and provide compacted lightly with a hand rammer. Plant grass to retain the material and to avoid that the material slip downhill to block the side drain.

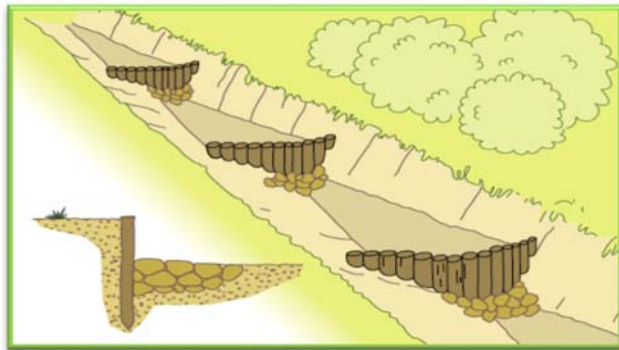
Step 4. Where the gradient of the drain is more than 4% construct scour checks to protect erosion

Quality control

- ✚ Make sure that the gradient in the catch water drain throughout its length is at least 2%.
- ✚ Make sure that the measurements are in accordance with the specified ones as shown in the drawing
- ✚ Make sure that water flows freely and directly into a cross drain.
- ✚ Make sure that the drain, depending on prevailing soil conditions and height of cut face, is not constructed too close to the cut face, where it may increase the danger of a land slip.
- ✚ Check that scour checks are used if gradients in the drain are too steep.

H-2 Scour checks

Scour checks should be constructed where road gradients of the side drain are steeper than 4% where the water in the drain will flow at a high speed which may cause erosion of the drains. The scour check is constructed to reduce the speed of the water and prevent from eroding the drains and road drainage structures. Scour checks



can be constructed by natural stone or with wooden or bamboo stakes depending on local available material. An apron of stones should be constructed downstream of the scour check. This apron will help reduce erosion downstream, which would be caused by the forces of water passing over the scour check.

Table below shows spacing of the scour checks in relation to the road gradients and soil conditions.

Gradient of road (%)	Scour check spacing according to soil conditions		Gradient of road (%)	Scour check spacing according to soil conditions	
	Good	Poor		Good	Poor
2	None	None	8	7.5m	4m
3	None	20m	9	6m	3m
4	None	15m	10	5m	2.5m
5	20m	10m	12	4m	Lining with masonry
6	15m	7.5m	15	Lining with masonry	
7	10m	5m			

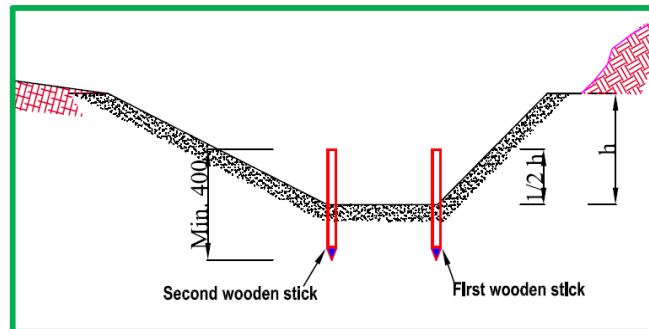
Construction of scour checks

Constructing the scour checks the steps below should be followed:

Step 1: Determine location of the scour checks. The spacing of the scour checks is determined based on the longitudinal gradient and soil conditions as indicated in the table above. Mark the locations of the scour checks with a pegs.

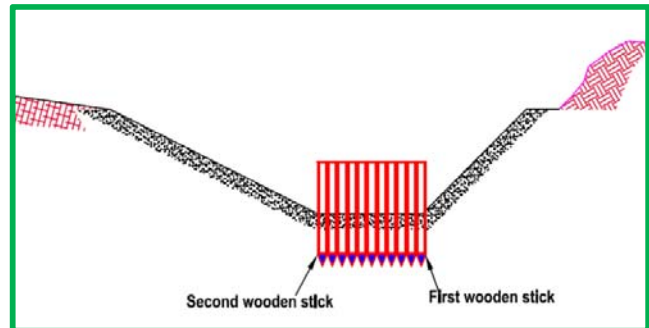
Step 2: Construct the wooden/ bamboo scour checks as the shape and dimensions shown in the drawing.

- Place the first bamboo or wooden stake at the edge of the bottom ditch and keep the height of $\frac{1}{2}$ of the depth of the side drain. Length the wooden stake should not be less than 40 cm. Place second stake at the other edge of the ditch and keep the height of $\frac{1}{2}$ of the deep.

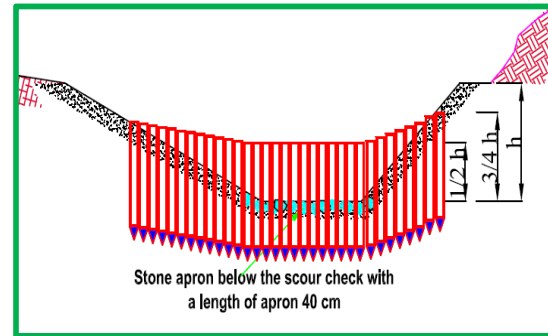


Place other stakes in between the two sticks until the entire width of the bottom of the ditch is covered.

- At the slope to continue gradually increase the height toward the top level of the both slopes. The height of the last stake should be $\frac{3}{4}$ of the depth of the side drain.

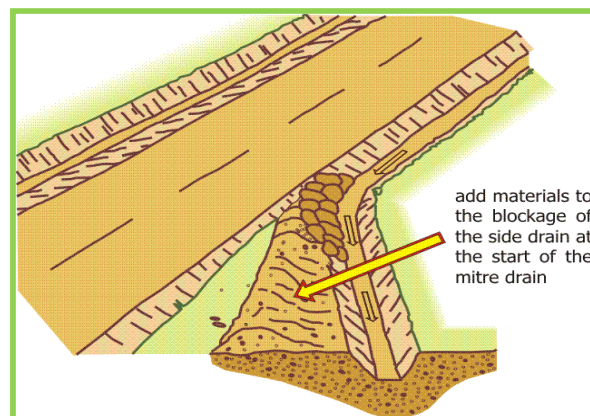


Step 3: After all the wooden stakes have been placed an apron is built immediately at downstream using stones. The stones should be placed in the ground and the top level of the stones should be same level of the bed of the side drain. Plant grass against the upstream face of the scour check wall to prevent water seeping through it. This will allow silting to commence on the upstream side. Later on it would be recommended to establish complete grass cover over the silted scour checks to stabilize them.



H-3 Mitre drains

The mitre drain (or turn out drain) is the drain that leads water away from the side drains to the adjoining land. Location of the mitre drain should be determined during the setting out of road alignment stage. Spacing from one to other mitre is based on the longitudinal gradient of the road. The steeper gradient of the side drain the closer spacing of the mitre drain. Table below shows spacing of the mitre drains in relation to the longitudinal gradient of the road and the gradient of the side drain.

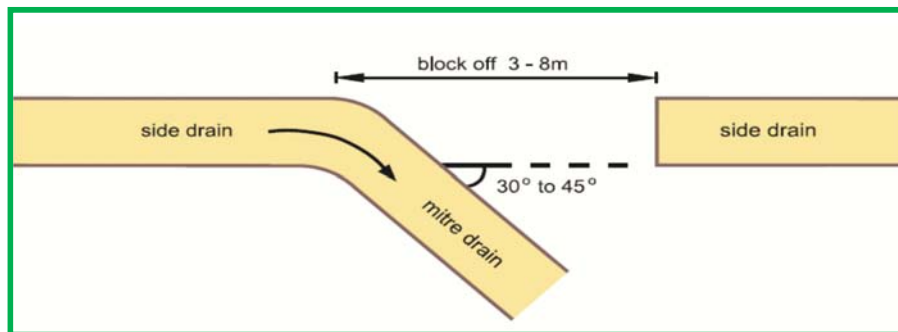


Mitre drains Intervals		
<i>Road longitudinal gradient (%)</i>	<i>Interval of should not exceed (m)</i>	<i>When discharging the water onto farmlands</i>
12	40	20-50m, wherever if possible into the boundaries between the farmlands
10	80	
8	120	
6	160	
4	200	
1-2	50 if excessive silting may occur	

The discharge water from the mitre drain should be channelled to farmland or to field boundaries if possible. Care should be taken to ensure the discharge water will not damage to farmland.

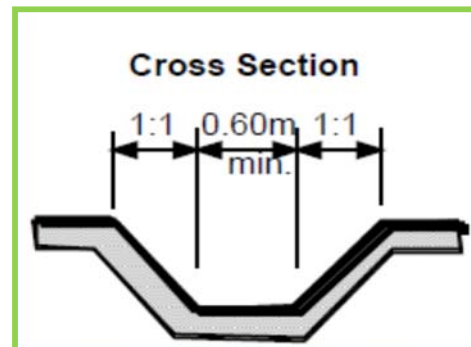
An effective gradient for a mitre drain is between 2-5 % and MUST not be greater than 5% as a steep gradient might cause erosion of the discharge area. The gradient of the mitre drain should be carefully checked to ensure that the gradient is within this limit. The width of the mitre drain should not be smaller than width the side drain as a narrow mitre drain might overflow with water from the side drain. The length of the drain depends on the terrain ground levels and the slope of the drain. Mitre drains should be as short as possible.

Construction of mitre drains



Step 1: set out the mitre drain should be done as shown in the drawing. The alignment of the mitre drain should be turned out from the side drain between 30°- 45° . Slopes of the mitre drain should be 1:1.

Step 2: Determine the gradient between 2-5% and then set out gradient of the mitre drain. To identify length of the mitre drain is based on the gradient and the existing ground level.



Step 3: Determine length of the block off between 3-8 m. Note, if locations of the mitre drains are known these 3-8 metres should be left untouched when excavating the side drain.

Step 4: Excavation of the mitre drain should be done as the method of construction of the side drain and to ensure the slopes on both sides. Pegs and string line should be used during the excavation. Use the excavated material as blockage on the inner side of the mitre drain.



Step 5: Put stone at the meeting point of the mitre drain and the side drain as shown in the drawing to avoid erosion.

Step 6: Where the gradient of the mitre drain is more than 4% scour checks should be constructed for the mitre drain.

Quality control

- ✚ Make sure that the mitre drains are set out at the correct locations where they can freely drain water away from side drains, without causing erosion on adjoining land.
- ✚ Make sure that the cleared width is about 4m to allow space for spreading spoil material from the drain.
- ✚ Make sure that the mitre drain is constructed to specified cross section.
- ✚ Make sure that bottom width and the gradients of the slopes follow specifications.
- ✚ Make sure that the mitre drain is excavated to a discharge point, from where the drain can freely discharge from the side drain.
- ✚ Make sure that the spoil material is spread out to the sides, to avoid spilling back and causing blockage of the drain.

H-4 Surface drains

One of the major causes to severe and quick damage to roads is the combination of surface water and traffic. Once the water stays on the road surface the water will penetrate into the road body and reduce the bearing capacity of the road base. The road surface will soften and with the weakened road base the load from the traffic on the road will easily develop potholes and rutting, and may cause the road to settle.

It is important to construct the road with an adequate camber to avoid surface water staying on the road. The camber is the slope from either side of the centre line towards the road shoulders. The road camber is built to lead the water from the road surface to the side drain and towards to the nearest drainage outlet. In most cases the camber is built with slope toward both side of the road edge (double-sided cross fall). In some cases the road is built with a slope



towards only one side (one-sided cross fall), for instance through a horizontal curve. For roads in mountainous terrain, some design specifications require the cross-fall to face the hillside of the road for safety reasons. With this design, there is a need to install a full drainage system.

The road camber should be designed according to the type of road and road surface material. For roads with an asphalt surface, the camber (cross fall) is normally between 2 to 4 percent, because water will easily flow off a waterproof surface. On earth and gravel roads, the camber needs to be steeper because the water will flow more slowly and the surface is often uneven. It is recommended that the road camber of a gravel road is constructed at 7 to 10 percent.

H-5 Cross drainage structures

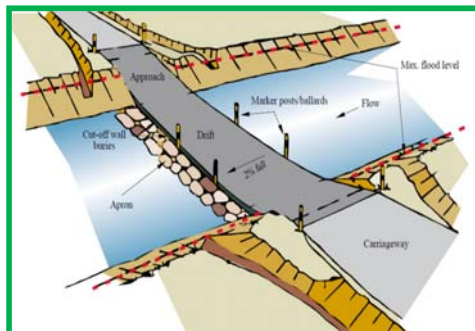
Cross drainage structures are the most important features of the road in order to keep the road in good condition and to keep the road passable to traffic throughout the year. There are many types of the cross drainage structures used in rural road design and construction. Structures are designed based on type of road, volume of water, type and volume of traffic. This module is introducing the most common types of cross drainage structures for rural roads.

Culvert

The culvert is a drainage structure constructed under the road and is designed to allow water from the drains and/or natural water course to safely cross under the roadway. There are different types of the culvert such as: concrete box culvert, concrete pipe culvert, steel corrugate metal pipe culvert. The selection of the culvert type depends on availability of local materials, skills and construction costs.



Drift (Ford)

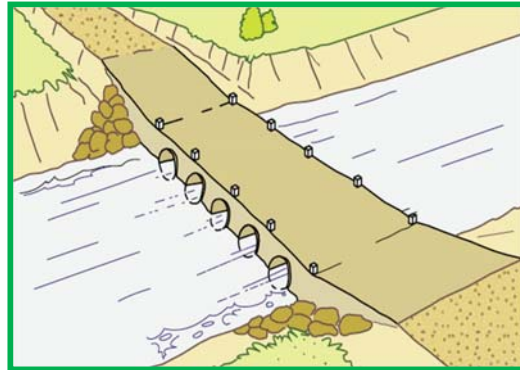


A drift is a low level drainage structure constructed to allow water from the drains and/or natural water course to safely cross over the road at bed level. The drift is designed to allow flash water to pass quickly. A drift should not be designed where

water will stay long and where it may block traffic for a long time. When selecting the drift as the cross drainage solution it is important to ensure that the stream or river is not too deep and knowing that water will reside quickly after heavy rains or flash floods.

Vented Ford (Vented Drift or Causeway)

A causeway is a medium level structure designed to allow the normal flow of water in a natural water course to pass safely through openings below the roadway and to be overtopped during periods of heavy rainfall. The causeway is the combination of drift and culvert. Similar to the drift, selection of the location to construct the cause way should consider where the depth of the stream or river is not too deep that can be passable by the traffic.



Bridge

Bridge is structure providing a means of crossing safely above water other obstruction whether natural or artificial. The bridge is designed to allow more water volume pass through. Bridge is the most expensive drainage structure of the road works. Careful design is a crucial job for the engineer. Bridges for rural roads can be constructed as wooden bridges, concrete reinforcement bridges, Bailey bridges, steel mix bridges.



LBT Training Manual

Module I

Graveling

Table of Contents, Module I Graveling

I	Graveling.....	3
I-1	Gravel	3
I-2	Planning for the graveling operation	3
I-3	Preparation of gravel quarry	4
I-4	Excavation and loading gravel.....	5
I-5	Hauling gravel.....	6
I-6	Work procedures.....	7
I-7	Off loading gravel	7
I-8	Spreading gravel.....	9
I-9	Watering and compaction of gravel.....	10
I-10	Dynamic Cone Penetrometer.....	12
I-11	Gradation test	14
I-12	Quality control for graveling work	15
I-13	Safety and health for graveling work	16

I Graveling

I-1 Gravel

Gravelling activity involves placing a layer of gravel (selected granular or laterite) material directly on the sub-base to provide a strong surface layer which is passable in both dry and wet weather, and which does not deform under the expected traffic loads. Together with the road camber, a good gravel surface will prevent water from entering into the road body and thereby avoiding surface water from deteriorating the bearing strength of the road.

In most cases, the gravel layer is placed immediately after the completion of earthworks. In some cases, newly constructed roads are left un-graveled for a period of time, allowing the base to settle and traffic to provide compaction. Graveling is also often a major part of periodic maintenance works on a road. Where in the case gravelling is mentioned, this can refer to both new gravelling and re-gravelling.

The graveling operation can be divided into the following activities:

-  Reshaping the road
-  Preparing the gravel quarry
-  Excavation and of gravel in the quarry
-  Loading
-  Hauling
-  Off loading
-  Spreading
-  Compaction

I-2 Planning for the graveling operation

Graveling is an expensive operation. Careful planning and control of resources and productivity rates is essential!

The organization of the labour gangs shall be balanced to suit available equipment and average haul times between the quarry and road site. The number of labourers required for excavating, loading and spreading of gravel is directly related to the target number of loads to be hauled. Particular attention should be paid to ensuring that sufficient amount of gravel is excavated for the following day's haul. The daily amount of gravel required is determined by the capacity of compaction equipment.

Daily plan: Compaction equipment, like other equipment, must be utilised to the fullest when deployed on site, as they are very expensive to rent. Furthermore, the availability of compaction equipment for rent is limited in Timor-Leste, in contrast to other equipment necessary for labour-based works. The daily planning for labour-based road construction activities should therefore be based on the availability and full utilisation of compaction equipment on site.

Daily planning should be based on the following process:

- ✚ Determine capacity of compaction equipment;
- ✚ Determine daily required quantities of gravel;
- ✚ Determine hauling distance and gravel haulage target;
- ✚ Allocate number of trucks required daily;
- ✚ Allocate labour to the activities to achieve daily target.

Example resource requirement for graveling:

- ✚ Two pedestrian rollers available on site can compact 450m² gravel daily.
- ✚ The width of the carriage way to be gravelled is 3.5m. Required compacted thickness of gravel is 0.12 m, and the loose thickness required is therefore be 0.15 m.
- ✚ The quantity of gravel required daily (based on the roller compaction capacity) is 450m²x0.15m = 67.5m³
- ✚ The capacity of one truck is 3m³ and one truck can complete 12 trips daily. One truck can therefore deliver 3m³ x 12 = 36 m³ daily. The total number of trucks required daily for the gravel operation is = 67.5 m³/ 36 m³ = 1.9 or 2 trucks
- ✚ Calculate number of labour required daily for the graveling operation:
 - o Work norm for gravel spreading is 5 m³ /Wd. The number of labourers required for spreading gravel is 67.5m³ /5m³ = 13.5 or 14 labourers,
 - o Works norm for excavating and loading of gravel is 2 m³ /Wd. Number of labour for this activity is: 67.5 m³ /2 m³ = 33.8 or 34 workers.
 - o Total daily number of labour for gravelling operation are: 14+34 = 48 workers

Summary: *The capacity of the rollers determines the scope of daily graveling operation. When the quantity of gravel has been determined, we can calculate the number of trucks needed and the number of workers to support the loading, and spreading operations.*

I-3 Preparation of gravel quarry

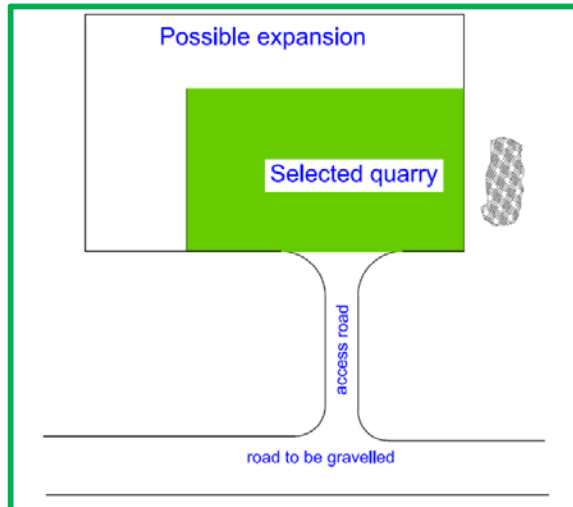
Make arrangements so that the quarry can be optimally exploited, environmental damage is limited, overburden can be stockpiled for quarry reinstatement, and the quality gravel can be extracted where the quality of the gravel varies.

Preparation of the quarry site consists of identifying the quarry, preparing the quarry access road, removing all vegetation, stumps, boulders, fences, structures, top soil and any other material considered unsuitable or inconvenient from the areas or those adjacent to gravel excavation site. The quarry must be approved by the

employer and before making decision to extract gravel form a quarry, the engineer must re confirm that the quality is acceptable based on simple field test.

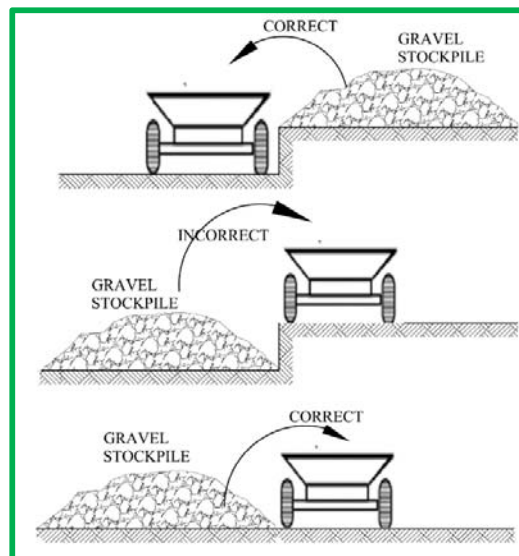
Work method

- ✚ Calculate total quantities of the gravel required to complete the road.
- ✚ Identify dept and thickness of suitable gravel that can be extracted
- ✚ Calculate area to be cleared based on the calculated quantity.
- ✚ Set out the boundary for the clearing using pegs and string line
- ✚ Clear all vegetation (including grass, bush, trees) and remove stumps, boulders, fences and structures.
- ✚ Haul and deposit all cut or removed materials to approved locations. Deposited material can be burnt only when approved by the Engineer.



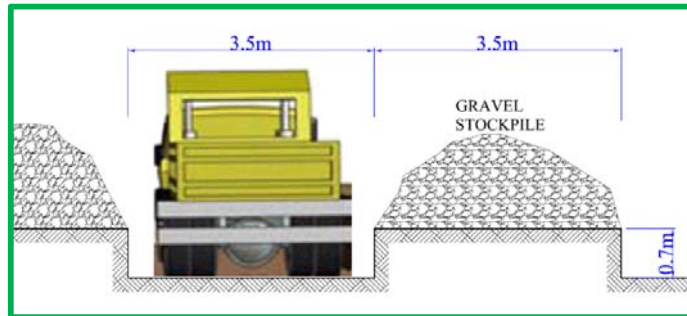
I-4 Excavation and loading gravel

- ✚ This activity involves the loosening of the **insitu** gravel, removing from cut position the loose gravel and stockpiling in heaps alongside for easy loading. It also includes removal of boulders encountered during excavations. This activity can be carried out either by labour or by excavator. If the loading will be done manually, it is important to keep the loading height less that 1.5 m. This can be arranged by excavating and stock pile the gravel and setting bay and direct the truck to the lower place for loading the gravel.



Work method

- ✚ Set out the place to be excavated and the place where the excavated gravel will be stock piled
- ✚ Excavate the gravel and stockpile it to be ready for loading. Sufficient gravel should be excavated and stockpiled one day before it is required to be hauled to the gravelling site.
- ✚ The gravel is stockpiled alongside the excavated area (as shown in the figure) to allow for easy loading.
- ✚ Loading gravel. Trucks should be parked at the same height as, or preferably below the stockpiles for ease of loading. The gravel is then loaded using shovels, down into or from the same height as the trucks.
- ✚ Continue with excavation to have sufficient stockpiled gravel for the following day



I-5 Hauling gravel

Hauling gravel can be managed in difference ways depending on hauling distance from the quarry to the road to be graveled and also depending on available of transport equipment.

Generally for short hauling distance the most economic means

of transportation are wheel barrows, baskets and stretchers. Such means of transport can be used when the gravel source is readily available in the vicinity of the work site. However, once the distance exceeds 150 metres, it is recommended to consider other means of transport.

For long hauling distance especially when the gravel quarry more than 150 m away from the road site, the above mentioned transportation mean is no more economic. It is recommended mechanical transportation mean such as truck or tractor with trailer.

Table above shows recommended mean of transportation related to the hauling distance.

<i>Hauling distance</i>	<i>Mode of transport</i>
0-20m	Baskets,
0-50m	Stretchers
10-150m	Wheel barrows
150-500m	Animal carts
150-2000m	Hand tractors
500-8000m	Tractor with trailers
More than 1000m	Trucks

Remember The loading must be matched to the haulage so that neither loaders nor haulage equipment have to wait unnecessary.

It is important to plan the hauling operation very carefully, thus ensuring that there is a good balance between labour and equipment during loading, hauling and unloading.

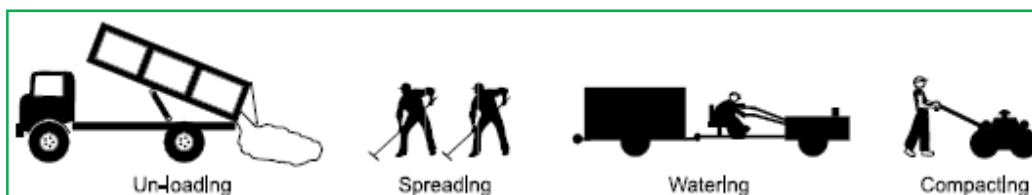
Haulage by trucks

Trucks with a capacity of 3 ~ 5 m³ of loose gravel is commonly used for rural road works in Timor-Leste. Haulage routes are often very difficult with steep gradients and poor road conditions etc. The table below is based on experiences from other countries and shows the number of trips one truck can carry during one day (8 hours). Gravel is loaded manually.

Typical haulage rates for manually loaded trucks		Equipment haulage productivities by tipper/truck per day (No of trips)			Remarks
Recommended productivities rate	Haulage distance	Good route	Fair route	Bad route	
	0.0- 2.0 km	22	18	16	
	2.1- 4.0 km	19	15	12	
	4.1 - 6.0 km	16	12	10	
	6.1 - 8.0 km	11	8	7	
	8.1 - 10 .0 km	8	6	5	

I-6 Work procedures

Before carrying out any gravelling works, first check that the camber of the earth works has been properly completed and reshaped to the exact and required standards. Placing the gravel, involves four activities, namely un loading, spreading, watering and compaction.



These activities need to be fine tuned with each other, achieving a good balance between labour and equipment

I-7 Off loading gravel

There are two ways to organize off loading of gravel, either towards or away from the quarry. The most common way to off load the gravel is towards the quarry.

Gravel spreading can follow the off loading activities and the truck does not have to pass by the graveled section thus minimizing damage to the completed section.

Hence the truck should turn towards the direction of the quarry, before unloading. This way it can return to the quarry without waiting for the material to be spread. There must be provision for turning places not to delay the haulage operation.



The spacing set out for each load of gravel depends on (i) the area of the gravel surface (ii) designed thickness of the gravel layer and (iii) the average load carried by each of the trucks. The site supervisor is responsible for calculating and marking with pegs and strings the spacing, where the gravel from the truck should be for off loading. The driver should be instructed to dump the entire load at the marked location. The spacing must be clearly visible to the truck driver.

Example calculation of spacing of truck loads of gravel:

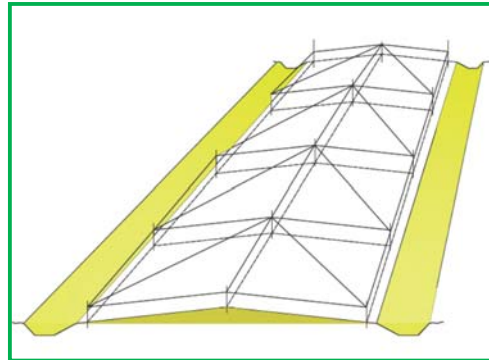
- With a carriageway width of 3.5 m
- and a designed gravel thickness of 12 cm compacted (loose 15 cm)

then one linear metre of the road will need a gravel volume as follows:

- Volume per linear metre: $0.15\text{m} \times 3.5\text{m} \times 1\text{m} = 0.525\text{m}^3$
- Volume of average gravel load: 3 m^3

this load covers a road section with the following length:

- $3\text{ m}^3 / 0.525\text{ m}^3 \text{ per m} = 5.7\text{ m}$

I-8 Spreading gravel

Once the material is off loaded, you can start the spreading. Spreading of gravel should ideally start immediate after off loading the gravel to make use of the natural moisture from the gravel. If the gravel is stock piled along the road for a period of days before leveling and compaction is carried out, it will dry out and will then require more water when compacted.

Work method

- ✚ Set out center line and edge of each box and ensure the cross fall is 10% loose (after compaction should remain min. 8%). Length of box should not be more than 10 m.
- ✚ Peg to be set at the edge and center line for every boxes
- ✚ Tighten string line at the center line, edge and cross fall.
- ✚ Spread the gravel within the set box. The gravel should be spread to the level of the set string line.
- ✚ Work from the centre line towards the shoulder, and spread one side of the centre line at the time. Keep some gravel beside each box after completing the spreading.
- ✚ Compact of the spread gravel lightly. Add the remaining gravel where in low spots appear during the compaction.



I-9 Watering and compaction of gravel

Watering procedure

The best compaction of the gravel can be achieved at the Optimum Moisture Content (OMC). If the gravel is too dry, friction between particles tends to resist close packing. If the gravel is too wet, the water between the particles prevents close packing. Control of moisture during compaction is very important and can be carried out through a simple field test by tightly squeezing a sample of the material in the hand. The material should be moist enough to stick together without any visible sign of water coming out of the sample. If the material disintegrates, it is probably too dry for compaction. If the soil sticks to the hand, it is too wet. If the gravel is wet enough you can form a ball, it contains the optimum moisture and is suitable for compaction.



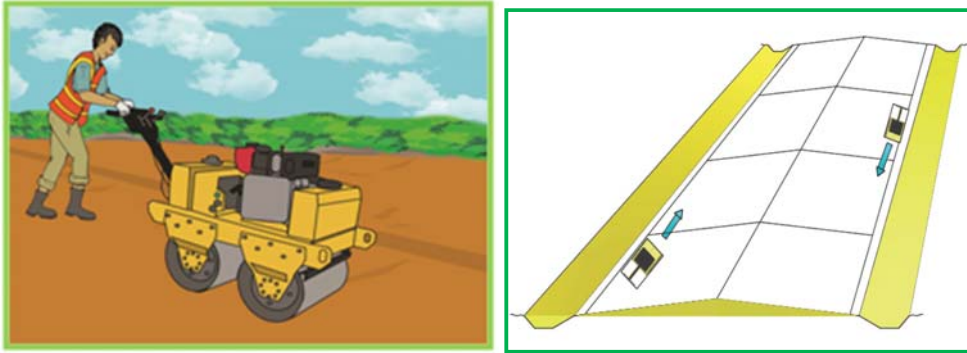
Remember: If the gravel is too dry you must add water to achieve Optimum Moisture Content (OMC)

Determine quantity of water needed to achieve OMC

1. After spreading is completed, collect a sample from the section that will be compacted. Place the sample of (V_1) in a container.
2. Add water gradually to the sample whilst mixing the material thoroughly. Place a little of the material in the hand and squeeze as above mentioned. Continue carrying out this test until getting optimum moisture content (OMC).
3. Determine the amount of water added to the sample (V_2).
4. Calculate the loose volume of material (V_3) onto which water should be applied. Volume of layer, $V_3 = \text{width} \times \text{depth} \times \text{length}$ (average dimensions of layer).
5. Calculate the volume of water (V_w) that should be added to the layer to bring it to optimum moisture content:

F - is a factor that moisture losses during sprinkling. F can be determined more accurately through trialing but theoretically ranges from 1.1 to 1.4

$$V_w = \frac{V_3}{V_1} \times V_2 \times F$$

Compaction

Compaction should be done by the appropriate method or equipment to suite the work specifications and conditions. Compaction of gravel should be carried out with a vibrating roller with approved total weight and dimension. Before applying the compaction equipment, the gravel should be spread evenly and the surface smoothness longitudinal and transversal checked. The gravel should be watered (to achieve approximate optimum moisture content) using water bowser with a sprinkler bar or by labour using watering cans.

Determine number of passes required for compaction of gravel (This method is applied when there is no soils laboratory on site or within reasonable proximity)

1. *Select a trial portion within the section about 10m long and 2m wide where gravel has been spread. Apply watering to Optimum Moisture Content. Place a steel peg on either edge of the portion about mid-way through its length. Hammer the pegs securely into the ground and ensure that the top of the pegs are at the same level. This can be achieved by pulling a line level tightly over the top of the pegs.*
2. *Pull a fine string over the top of the pegs and mark on the string the position of the pegs and about 5 intermediate points between the two peg marks preferably at equal intervals.*
3. *While the string is in position measure and record the height of the string at each point from the top of the gravel surface layer.*
4. *Remove the string and apply one pass of the available roller. Stretch the string again, and measure and record the heights of the points on the string.*
5. *Repeat the procedure until approx 10 passes of the roller.*
6. *Calculate the average height after each pass and plot a graph of average height against number of passes N. Or preferably plot the difference in height (H) in millimetres against passes, where H_i is the average change in height as a result of pass number N_i . Read from the graph the value of N when $H < 1\text{mm}$. Round off the value of N to the nearest whole number.*

7. Add 2 more passes to the number of passes obtained in (6) above and express the total as the specified number of passes (Ns) to achieve adequate compaction for approval.

Once the number of passes required to achieve adequate compaction has been determined, the next stage is to carry out the compaction as per procedure below.

Compaction procedure

For the compaction by roller, the work should be carried out along the road line starting at the edge to road and gradually working towards the centre line. Maintenance speed of the roller is about 1 km/hrs. It is important to always compact in vibratory mode. The wheel track should be overlapped 20 cm. A minimum number (to be specified by the Engineer) of passes of compaction shall be applied or until no roller imprint on the surface can be recognized.

Make sure that the camber of the road is always maintained at a minimum of 8% for both the base layers as well as the gravel layer. After compaction, it is important to check that all levels are correct and that the surface is smooth and does not contain any uneven spots.

Remember: Make sure that you have sufficient supply of water, in order to maintain an optimal moisture content in the soils which are being compacted.

Table below shows compaction equipment and recommended number of passes

Type of roller	Capacity of the roller (kg)	No of passes for layer not greater than (cm)			
		Earthwork/fill		Gravel	
		12	15	12	15
With vibration	700- 1200	12	15	15	Unsuitable
	1200 - 3000	8	10	8	15
Dead weight	Above 3000	8	10	15	>15*
Note: * To trial a section to compact and count number of passes until "refusal". The number of passes will be used for further compaction					

I-10 Dynamic Cone Penetrometer

When specifying the end result, the required level of compaction is normally prescribed relative to a laboratory compaction test. For example, compaction to 95% means that the dry density of samples taken in the field should be 95% of the dry density obtained in a specified laboratory compaction test. Alternatively,

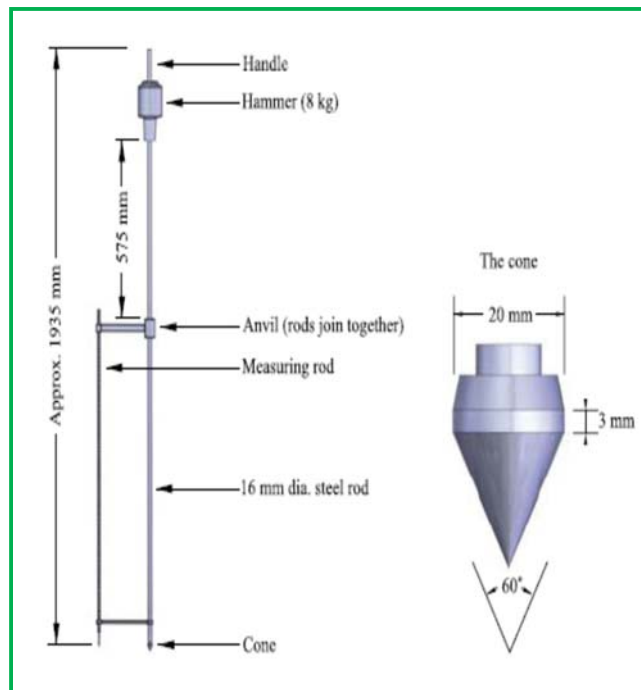
the percentage of air voids can be used as a reference to the degree of compaction. Today, there are a number of methods to check the results of compaction – some can be carried out in the field and others require laboratory facilities. For rural road works, the cone penetrometer is commonly used to verify compaction results. The advantage of this test method is that it can check the degree of compaction through several layers.



The DCP is an instrument designed for the rapid in-situ measurement of the structural properties of existing road pavements and base/sub-base layers with unbound materials (earth or gravel for example) and also designed for density test.

A correlation can be established between the DCP measurements and the California Bearing Ratio (CBR) so that results can be interpreted and compared with CBR specifications. This instrument is easy to use in the field and provides quick results. It is often used on labour-based road sites.

The DCP is a portable tool comprising a rod with a pointed end, which is driven into the ground or layer with a weight sliding on the rod between two stops. The penetration is measured for every blow or every five blows and is converted to CBR strength from a table.



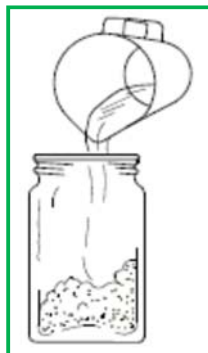
This instrument requires a minimum of two people for operation and testing. Once the instrument is vertically assembled the hammer is raised to the upper stop and released to fall onto the lower stop, driving the point of the DCP some distance into the ground. The hammer is raised again and released to drive the point further. After each blow the reading on the rule is recorded. Result for the reading shall be recorded in the table below.

[illegible]

Note: DCP values should be measured immediately after the layer has been compacted, while the soil is at or near optimum and a reasonably true value will be obtained.

I-11 Gradation test

Before accepting any gravel quarry for the graveling works, it is advisable to take a sample of the gravel for testing to confirm the quality. In general the quality test should be conducted in laboratory. It should be recognized that in many places good laboratory facilities are limited. In addition, laboratory tests can be expensive and time



consuming and not practical for remote and dispersed projects, which are the most suited to labour-based methods. Therefore Engineers also should carry out some simple field test prior to making decision about the suitability of the gravel. If the field test results in a doubt about the quality, then the laboratory test is necessary.

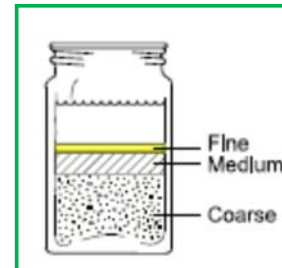
Settling (bottle) Test

This test can determine the proportions of the various gravel fractions in a sample. To carry out the test, first take a sample put in a glass jar about half filled. Then add water till the jar of about three-quarters full. Add some salt that can help for the

setting of the finer material. Shake the jar, and leave the jar for some time. The coarse material will then settle first followed by finer material. The clay and the fine silt will remain in suspension for some time before they settle.

You can see the proportion of each fraction as layers in the jar. From this result, we can take measure the layer of the material in the jar. The good gravel material should contain proportion grading between:

- + Stones (coarse gravel) 35 - 65%
- + Sand 20 - 40% and
- + Clay 10 - 25% .



The results of these tests can only provide indications on how these gravel could react when subjected to compaction, traffic and weather conditions.

I-12 Quality control for graveling work

The graveling activities include quarry preparation, hauling gravel, spreading and compaction of gravel surface. Quality control and test for these works include checking the suitability of the gravel quarry, grading and plasticity of the gravel, check thickness and compaction of each gravel layer. Some test can be carried out in the field and some test should be done in laboratory if required by a client.

Description/ work activity	Test/check method	When	Tools
Identification of gravel quarry	✓ take a sample from a gravel quarry ✓ conduct grading test: bottle test or sieve analyse(refer to specification) ✓ Plasticity. Test for PI (required PI should be 6-15) ✓ CBR test: Required CBR >10%	Before commencing delivery of the gravel to road site	Lab equipment
Delivery of gravel	✓ visual inspection, check volume of gravel supplied by each truck ✓ ensure that pegs are placed where the truck should offload the gravel ✓ Check that camber of the road formation before gravel is off-loaded. ✓ visual check over size material	During delivery of gravel	Measuring tape
Spreading gravel	✓ visual inspection, check for every cross section the width of the road and thickness of gravel to be spread. ✓ ensure pegs and string line are used for every cross section (every 10m interval) ✓ Check at random that oversized material (> 63mm) is crushed with a hammer. ✓ check that gravel is spread evenly before commencing dry compaction ✓ watering to an optimum moisture content (OMC) ✓ randomly counting passes of compaction to the required passes. compaction to the	During carrying out the activity	Measuring tape, Line level or camber board, DCP or sand placement equipment

	required degree		
	✓ visual inspection, check evenness of the surface ✓ visual inspection, check the camber for every 20 m ✓ visual inspection, check thickness of the gravel layer ✓ perform compaction test (DCP or sand placement test) for every 50 m. accepted CBR > 25 %	After completion	
Final check for finishing work	✓ ensure that all excess material has been cleared from site ✓ excavated material is spoiled away from road formation and as instructed by the client engineer ✓ borrow pits have been levelled, trimmed or refilled as applicable	After completion of the work	NA

I-13 Safety and health for graveling work

This includes the provision of general safety and health measures for labourers on site for the graveling work..

I-13-1 Safety Measures

-  Carry out a safety briefing for all workers before works begin. Make sure work is organized so that each worker has enough space to carry out his or her task without endangering co workers.
-  Place warning signs or cones at each end of the work area. The warning signs should be placed 50-100 m away from the working areas. The text on the warning signs should read: "KUIDADU" or "HALAI NENEIK"
-  All equipment operators must be trained in the use of their equipment (trucks, rollers, etc). Equipment must be in good condition and safety covers for moving parts should be used.
-  Deep excavations for gravel quarry shall be made safe by ensuring a sufficient angle of the slope so that they do not fall onto workers in the excavation.
-  No children are allowed enter in the work area.
-  The contractor shall not allow the use of alcohol or drugs on the works site or in the site camp.

I-13-2 Drinking water:

Drinking water must be available within 50 metres of all work sites approximately 2 litres should be available per worker per day

I-13-3 Safety Gear:

The workers shall be provided appropriate safety gear in sufficient numbers. All workers must be instructed how and when to use safety gear and items shall be replaced when unusable or lost: The safety gear as listed below.

- + Safety jackets in bright colours for supervisors and for all workers if working on a road that has frequent traffic
- + Closed shoes and gloves for all workers for general road works. Note that cotton gloves need to be replaced regularly
- + Gum boots and good quality gloves when working with sharp tools (e.g. pick axes), Carrying heavy loads and working in muddy places
- + Hard hats for workers working in danger deep quarries or under a bridge, etc.
- + Dust masks when working with activities that produces lot of dust or bad smell. Note that dust masks must be replaced regularly
- + Safety goggles must be used when breaking rock or crushing stone or anytime there is a risk for eye injury

I-13-4 First Aid:

A first aid box must be provided on site and must be regularly checked and restocked.

LBT Training Manual

Module J

Surface options

Table of Contents, Module J Surface options

J	Surface options	3
J-1	Type of surfaces.....	3
J-2	Layers of road pavement.....	3
J-2	Sub-base	4
J-2-1	Materials specification for the sub-base layer	4
J-2-2	Work method	5
J-3	Road base course	7
J-3-1	Materials specifications for the road base course.....	7
J-3-2	Work method	8
J-3-3	Quality control for construction of sub base and base course.....	9
J-4	Bituminous surface.....	10
J-4-1	Bitumen.....	10
J-4-2	Cutback bitumen.....	11
J-5	Application of prime coat.....	11
J-5-1	Work method	11
J-6	Penetration Macadam (Pen-Mac) surface	12
J-6-1	Materials	12
J-6-2	Work method	13
J-6-3	Hand tools and equipment	15
J-6-4	Quality control for construction of prime coat and penetration macadam	16
J-6-5	Health and safety for bitumen work.....	17
J-7	Construction of plum concrete surface.....	18
J-7-1	Material.....	18
J-7-2	Work method	19
J-7-3	Quality control for construction of plum concrete surface	22
J-8	Stone surface.....	23
J-8-2	Material.....	23
J-8-3	Work method	24
J-8-3	Quality control for construction of stone surface	26
J-9	Safety and health for construction of road base course, bituminous surface, concrete and stone surface.....	28

J Surface options

This module provides guidance on the construction of bituminous seals, stone pavements and concrete surface options on low traffic roads using labour-based technology (LBT). It is aimed to small scale contractors who are responsible for carrying out the work employing mainly local labour. Decision to surface a road with a bituminous seal, stone paving and concrete paving is made as to reduce maintenance cost where the gravel surface requires too much maintenance or in some cases where suitable gravelling material is not available. The techniques described in this module use low cost plant and material that can be found in the country.

J-1 Type of surfaces

There are many types of road surfaces that can be used for rural road construction. The choice of road surface depends on a number of factors, including road category, type and volume of traffic, condition of terrain, climate and budget. For the purpose of rural road construction in Timor-Leste, this manual provides information on some of the more common options used to provide the basic all-weather access. The commonly used surface options for rural road construction in Timor-Leste are:

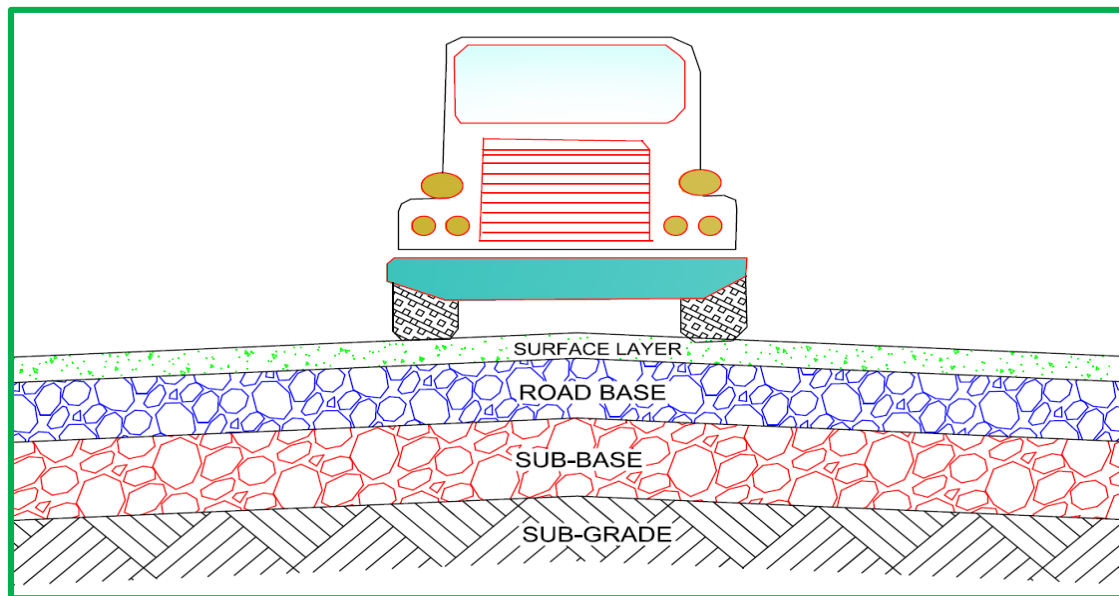
-  gravel surface road,
-  concrete surface road,
-  stone surface road and
-  bituminous surface road

Gravel surface roads are often referred to as roads with gravel wearing course which is appropriate for roads with limited traffic, gentle longitudinal gradient and moderate rainfall intensity. This module describes construction of rural roads with bituminous surfaces, concrete surfaces and stone surfaces as the gravel surface road has been described in another module.

J-2 Layers of road pavement

Roads are built in several layers consisting of sub-grade, sub-base, road base and surface layers. These layers constitute the road pavement. Each layer of road pavement has its own function and has different strength. Thickness and material of each layer is designed based on road category, volume and type of traffic (type of in situ soil and climate can also impact on the thickness of the layers). Available budget, location of the road and the availability of suitable local materials are key parameters, which also need careful consideration. The pavement can be constructed from a wide variety of materials ranging from gravel, stone, bitumen, concrete or improved soils. This module describes layers of constructing road sub-base, road base course and bituminous surfacing layer, concrete surface and stone surface layer which are commonly used in Timor-Leste.

Different levels of traffic require difference material and thickness for road pavement. The figure below shows different layer of the road pavement.



J-2 Sub-base

The sub-base is a layer of pavement that is placed directly on the natural soil, the sub-grade. The sub-base acts as a separating layer between the sub-grade and the road base and similarly to the road base provides additional strength to the road but with less strength requirements compared to the road base.

J-2-1 Materials specification for the sub-base layer

Materials selected for use for as sub-base layer may be obtained either from river gravel with a minimum percentage of broken stones, or mountain gravel and shall meet the requirements as shown in the table below, and shall be free of lumps of clay, organic, or other deleterious materials.

Grading Requirements for sub base Material

Sieve Size		Percent by Weight Passing
ASTM	(mm)	
2"	50	100
1" 1/2	37.5	80-100
1"	25.0	75-100
3"/8	9.5	50-75
No.4	4.75	35-65
No.10	2.00	25-50
No.40	0.425	15-30
No.200	0.075	5-20

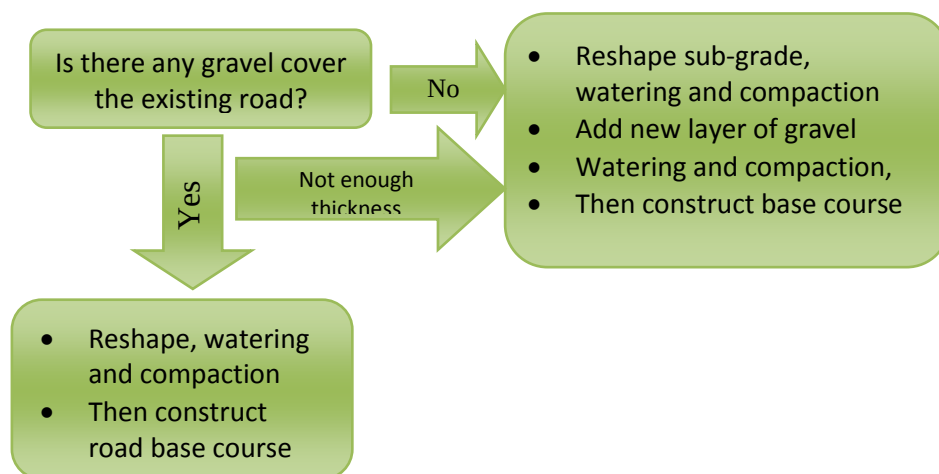
In addition to grading requirements the material shall also meet the property requirements as shown in the table below:

Properties for sub base Material

Property	Requirement
Liquid Limit LL (AASHTO T 89)	Max.40 %
Plasticity Index PI (AASHTO T 90)	Max.12 %
CBR of 98% MDD of AASHTO TO 180	Min. 30 %

J-2-2 Work method

In many cases the asphalt road, concrete and stone surface roads are constructed by up-grading an existing gravel road. In such case the existing gravel road may still have gravel remaining on the road surface. When upgrading this road the engineer should make an assessment of condition and amount of gravel cover on before deciding whether to construct or upgrade the sub-base. The graph below is a guide for making the decision to construct or upgrade the road sub-base:

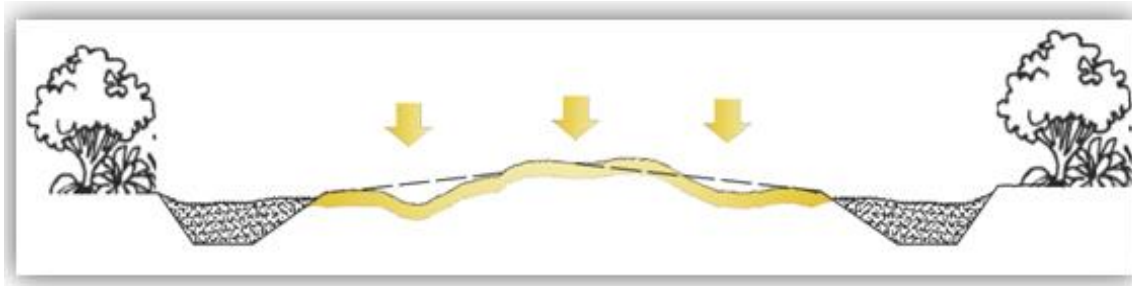


a- Reshaping an existing sub-grade

Before placing sub-base material or providing additional layer for sub-base, the existing sub-grade requires restoring to the required road shape. The activity will include re-establishment of road camber (cross-fall), shoulders and slopes to enable the water to drain off easily. Reshaping can be done by labour-based methods or grading by equipment. The choice of technology depends on the viability in respect of cost. In this guideline the reshaping



activity is carried out using labour-based method.



- ✓ Before starting the work, place warning signs on either side of the worksite.
- ✓ Setting out road cross section with cross fall (camber) 3-5%. The camber cross fall should be set depending on the selected type of road surface for the road. Using pegs and string line to control level of the road during execution of the works. Setting out for road cross section should be done for every 5-10 m interval. Minimum 3 pegs are set for each cross section: 1 at center line and 2 pegs for at road shoulder.
- ✓ Any vegetation from the carriageway or shoulder is removed and dumped on the lower side of the road, using a hoe or rake.
- ✓ Trimming the surface material with hoe or pick axe to restore the road surface shape, bringing the materials from the sides to the centre and forming to the required camber cross-fall.
- ✓ Spraying water to the optimum moisture content and compaction using roller to required strength or compact until "refusal".

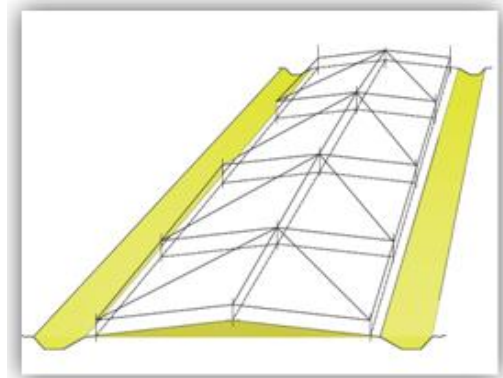
b- Provide additional material for sub base layer

The sub-base construction can be carried out once the existing road surface (sub-grade) has been restored to the required shape. The sub base construction activity is normally carried out with additional gravel layer to restore the thickness of 12- 15 cm after compaction. The required additional material depends on the remaining gravel on the existing road surface and designed thickness of the sub-base. The activities can be carried out using a a labour-based approach with support from light equipment. It is important for the planning of the labour work force to know the capacity of the supporting equipment such as roller and water bowzer, as this will determine how many people will be required to carry out the work.



The sub base construction activity shall be done following the same steps of graveling activity such as selection of gravel quarry, loading, hauling, unloading and spread gravel, watering and compaction.

- ✓ Whenever sub base construction activities are carried out on a road with traffic, a diversion should be opened for traffic and routine safety measures should be taken, such as putting up traffic signs etc.
- ✓ Gravel should be obtained from a quarry as near as possible. The gravel must be of good quality and taken from the place identified by the engineer.
- ✓ Deliver the selected gravel on site. The spacing between the unloaded heaps of gravel should be calculated based on the volume required for each section, which is determined by the designed road width and thickness of gravel.



Spreading gravel

- ✓ Set out center line and edge of each section (box) which should not be more than 5 m in length and ensure the cross fall is 3-5%.
- ✓ Pegs should be placed at the edge and center line for every box.
- ✓ Tighten string line at the center line, edge and cross fall.
- ✓ Spread the gravel within the set box. The gravel should be spread to the level of the set string line.
- ✓ Spread the gravel from the centre line towards the shoulder, and spread one side of the centre line at the time. Keep some gravel beside each box after completing the spreading.
- ✓ Dry compact of the spread gravel lightly (1-2 passes) by roller. Add the remaining gravel where low spots appear during the compaction.
- ✓ Watering and compaction to the required strength. For the sub base layer, it is recommended that CBR converted from DCP test should be $> 30\%$.



J-3 Road base course

Road base course is a layer of pavement covering the compacted sub base layer and immediate under the surfacing layer. The road base course is the main layer in terms of providing additional strength and load bearing capacity to the road.

J-3-1 Materials specifications for the road base course

Commonly, materials selected as base-course layer consists of crushed and graded materials from a stone crusher with broken stones and mix with stone dust. The selected material shall meet the requirements as shown in table below and shall be

free of lumps of clay, organic, or other deleterious materials and shall have a quality such that a stable road surface can be obtained.

Grading Requirements for Base Course Material

Sieve Size		Percent by Weight Passing	
ASTM	(mm)	Class A	Class B
2"	50		100
1 ½"	37,5	100	88 - 95
1"	25,0	79 - 85	70 - 85
3/8"	9,50	44 - 58	30 - 65
No.4	4,75	29 - 44	25 - 55
No.10	2,0	17 - 30	15 - 40
No.40	0,425	7 - 17	8 - 20
No.200	0,075	2 - 8	2 - 8

Conditions of Aggregate for Class A and Class B

Property	Class A	Class B
Abrasion of Coarse Aggregate	0 - 40 %	0 - 40 %
Plasticity Index	0 - 6	0 - 10
Liquid Limit	0 - 25	0 - 35
Soft Part	0 - 5 %	0 - 5 %
CBR	min. 80 %	min. 35 %

Note: Class B material can be used for base course layer for low traffic volumes which is usually is the case for rural roads.

J-3-2 Work method

The base course layer can be carried out once the sub base layer has been constructed. Road base course materials shall be placed directly on the road sub base and spreading shall be carried out using appropriate hand tools. Road base-course shall be constructed in layers to the designed level. During construction, an adequate camber according to the drawings shall be maintained at all times. The layers is commonly constructed to a thickness of 120 to 150mm. The construction method is the same as for the construction of the sub base layer, as described above.



Minimum required CBR after the compaction shall not be less than 80% as of the result converted from the DCP test.

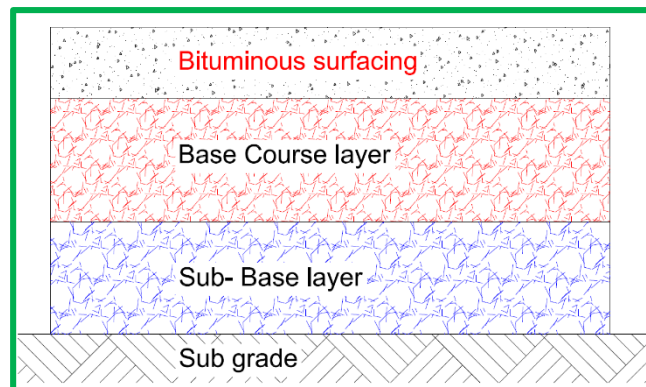
J-3-3 Quality control for construction of sub base and base course

The construction of sub base and base course activities include selection of material, spreading and compaction. Quality control and test for these works include checking the suitable, grading and Plastic Index (PI) of the material, check thickness and compaction of each gravel layer. Some test can be carried out in the field and some test should be done in laboratory if required by a client.

<i>Description/ work activity</i>	<i>Test/check method</i>	<i>When</i>	<i>Tools</i>
Material (gravel for sub base and crushed stone gravel for base course)	✓ Take a sample of gravel for sub base material from a gravel quarry for testing. For base course material the sample should be taken from a crusher for the testing. ✓ conduct grading test: sieve analyse(refer to specification) ✓ Plasticity. Test for PI (for sub base material) ✓ Conduct proctor test ✓ CBR test: Required CBR for sub base refer to specification	Before commencing delivery of the material on site	Lab equipment
Delivery of the material	✓ visual inspection, check volume of material supplied by each truck ✓ ensure that pegs are placed where the truck should offload the material ✓ visual check material must be clean free of grass, tree leaves, organic material..	During delivery of gravel	Measuring tape
Spreading sub base /and base course	✓ visual inspection, check for every cross section the width of the road and thickness of sub base and base course to be spread. ✓ ensure pegs and string line are used for every cross section (every 5m interval) ✓ check that the sub base and base course material is spread evenly before commencing dry compaction ✓ watering to an optimum moisture content (OMC) ✓ randomly count passes of the compaction and ensure compaction to the required degree	During carrying out the activity	Measuring tape, Line level or camber board
	✓ visual inspection, check evenness of the surface ✓ visual inspection, check the camber for every 20 m ✓ visual inspection, check thickness of the sub base and base course layer ✓ perform compaction test (DCP or sand placement test) for every 50 m. accepted CBR for sub base > 25 % and for base course CBR>85 %	After completion	DCP or sand placement equipment
Final check	✓ excavated material is spoiled away from road formation and as instructed by the client engineer ✓ borrow pits have been levelled, trimmed or refilled as applicable	After completion of the work	NA

J- 4 Bituminous surface

The bituminous surface is the last layer of the asphalt road. This layer is immediately covering the layer of road base course and is in direct contact with the traffic. In some cases this layer is constructed to contribute to the load bearing capacity of the road while in other cases they only act as surface treatment layer.



There are several types of bituminous surfaces that can be constructed to acceptable standards by labour-based methods supported by simple plant such as hand sprayers, concrete mixture and light rollers and light dump truck.. These includes bituminous surfaces such as Penetration Macadam, Asphalt sand seal, DBST (Double Bituminous Surface Treatment), SBST (Single Bituminous Surface Treatment), Cold mixed asphalt, etc. Selection of an appropriate bituminous surface will depend on the road characteristics such as traffic volumes, available materials and equipment, gradients, etc. Bituminous surface options can be constructed in different ways using a wide variety materials. Some needs to be premixed using mixing plant or manual mixing, and others can be produced by mixing the ingredients on site.

For rural roads, where traffic loads usually are very low, the thickness of the bituminous surface layer can be significantly reduced. Often, only a thin surface layer is laid over a base course consisting of natural gravel or crushed and screened aggregates.

Most bituminous surface seals consist of a coat of bitumen in which aggregate, gravel or sand has been embedded. Some bituminous surfacing layer such as penetration macadam and some hot mix asphalts, can perform both as surface treatments and also contribute to the load bearing capacity of the road.

J-4-1 Bitumen

Bitumen is widely used in the construction industry due to its waterproofing and adhesive properties and commonly used in road pavements as a bonding and sealing. Most bitumen is obtained from crude oil, essentially being the leftover. At room temperature, it varies in texture from solid to a sticky liquid. When heated it melts and turns into a low viscosity fluid. Bitumen needs to meet specific performance requirements. During construction the bitumen needs to be soft enough to (i) mix with the selected aggregates and (ii) adequately viscous to spread on a road surface. Once it has been applied, the performance requirements a hard and durable surface which resists weather conditions and traffic.

At room temperature, bitumen ranges from semi-fluid to solid, so it is normally heated to 150 to 200 °C before being spread on a surface or mixed with aggregate. Different grades of bitumen are applied to pavements using a variety of work methods depending on the prevalent weather conditions, expected traffic loads and

type of aggregate being used. In general, harder penetration grades are used in warm climates and softer grades in cold environments.

J-4-2 Cutback bitumen

Cutbacks are classified as rapid curing (RC), medium curing (MC) or slow curing (SC). The cutbacks are produced by adding solvents such as naphtha (RC), kerosene (MC) or diesel (SC), which eventually evaporates, leaving behind a stiff binder. As all the solvents are flammable, the use of cutbacks requires stringent safety measures to ensure safe handling during storage and application.

J-5 Application of prime coat

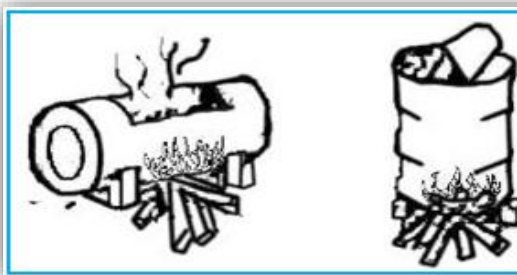
When a bituminous surfacing material is applied to the base course layer it is important that the base course layer is dry, clean and dust free. Priming helps to improve adhesion between the road base and bituminous surface. It also seals surface pores in the road base. The work consists of the preparation of the base layer, and the application of prime coat.

J-5-1 Work method

Preparation of base: remove dust and loose material from compacted road base using air compressor or alternatively using brooms. The sweeping shall be done carefully not to damage road base and no longer than 24 hrs before applying the prime coat.

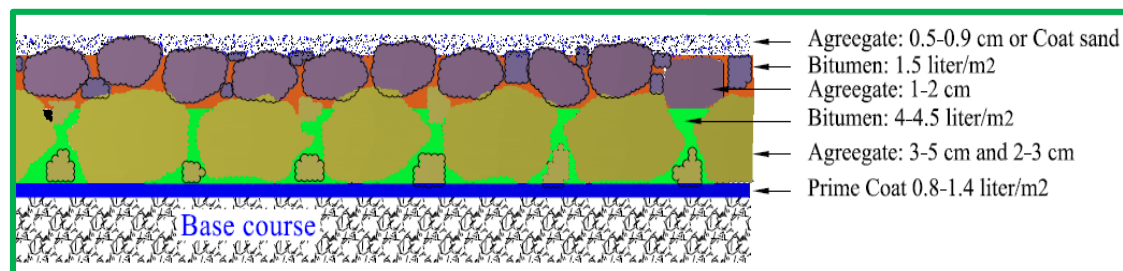
Apply Priming using Cutback bitumen

Heat bitumen to required temperature (120 to 150 °C). The bitumen shall then be mixed with kerosene in proportion 35-40% of total volume. Heating bitumen should be done by heater tank alternatively heating the bitumen by heating its own drum with fire wood as shown in the figure below.



- Spray the cutback onto the cleaned road base using a bitumen sprayer. The recommended bitumen cut back spray rate is 0.8-1.4 litres/m². The application amount of cutback depends on the density of the road base course and special instructions given by the engineer. The depth of penetration of Prime Coat should be minimum 3-10mm and the quantity sprayed should be such that the surface is dry within a few hours. Normally a prime coat is applied 24 hours before the construction of a surface treatment and shall not be subject to traffic over this period.

J-6 Penetration Macadam (Pen-Mac) surface



Penetration Macadam surface is a surfacing option that is commonly used in Timor Leste. This type of surface is suitable for rural roads with higher traffic density and road sections with steep gradients. Bitumen for the Penetration Macadam can be cold emulsion or hot bitumen depending on local availability and price in locally. Crushed aggregate is normally used because this material helps to generate a stable interlocking layer after it has been compacted. A heavy (6-8 Tonnes) roller should be used for compaction.

Based on experiences from Timor-Leste and elsewhere the use of Penetration Macadam road construction methods can yield good and durable results for low to medium traffic rural roads. The construction of a penetration macadam surface can easily be done in rural areas, eg through communities, and is well suited to a labour-based approach. The labour-based approach and use of locally suitable materials create employment and income opportunities for rural communities. The technology has a number of advantages:

- ✓ Cheaper than normal asphalt construction technologies
- ✓ Work method is suited for Labour based approach
- ✓ Can use crushed stone which is manually produced, which could create significant employment opportunities

J-6-1 Materials

The Penetration Macadam construction process is done in a number of different layers. Each layer of the Penetration Macadam consists of different sized aggregates and bitumen. The macadam layer can be spread using manual labour and hand tools. A completed Penetration Macadam surface layer is as a minimum 50 mm thick.

Aggregate

The quality of the coarse aggregate is the key to a good Penetration Macadam surface. The preferred material is crushed or broken stone. Angular stone is preferable as it provides better interlocking and a denser structure. The aggregate used for this surfacing layer consists a particle size ranging from 5 mm to 50 mm. The normal source of the fine material is from the crushing process when producing the coarse aggregate. It is also possible to use natural sources of coat sand instead of crushed fine aggregate in the top layer of the surface. Clean crushed aggregate produced by hand knapping and screening can be used for the Penetration Macadam.

The aggregates for the Penetration Macadam layers shall consist of coarse aggregates. The required sizes are: 30-50 mm, 20-30 mm, 10-20 mm and 5-9 mm(or coat sand). Before commencing the work, the aggregates shall be delivered and stored separately to prevent mixing and shall be kept clean of foreign matters.

Bitumen: The bitumen binder shall be any one of the followings: Penetration grade bitumen 60-70 pen or 80-100 pen.

J-6-2 Work method

- The different sizes of crushed aggregate to be used for the penetration macadam surface shall be placed along the road in orderly arranged heaps.
- Apply the first layer of crushed aggregate of sizes 30-50 mm, interlocked with aggregate in sizes 20-30 mm at an amount rate of about 80-100 kg/m² on the primed surface uniformly. Apply compaction immediately using an 6-8 tons steel wheel roller for 8-10 passes at a speed of not more than 3 km/h.





- Spray heated bitumen on the compacted coarse aggregates. Application rate shall be 4.0 litres to 4.5 litres/m², applied as uniformly as possible at the temperature stated in the specification.
- While the first application of bituminous material is still warm and plastic, the second layer of aggregate of sizes 10-20 mm is spread uniformly at a rate of about 20 to 25 kg/m². Apply compaction immediately using a 6-8 tons roller for 8 - 10 passes at a speed of not more than 3 km/h.
- The next layer of bitumen is to be sprayed at a rate of 1.5 litres / m² on top of the previous compacted aggregate layer at temperatures stated in the below table.



- While the bituminous material is still warm and sticky, the third layer of fine aggregate or coat sand in sizes 5mm to 9mm (or aggregate chippings) shall be spread at a rate of about 8-10 kg/m². Apply compaction immediately using a 6-8 tons roller for 3-5 passes at a speed of not more than 3 km/h. The last passes shall make sure the final surface is smooth and even.
- Table below provides summary of the material required for each layer of Penetration Madam and the required temperature for heating bitumen

Details of materials applied per square meter (m²) of Penetration Macadam surfacing

Type of Material	Penetration Macadam thickness 50-60mm
1 st Layer: coarse aggregates size 30-50mm interlocked with aggregate size 20-30mm	80-100 kg/m ²
1 st Layer: spraying bitumen	4 - 4.5 litres/ m ²
2 nd Layer: aggregates size 10-20mm	20-25 kg/m ²
2 nd Layer: spraying bitumen	1.0-20 litres/ m ²
3 rd Layer: aggregate size 5-9mm (or coat sand)	8-10 kg/m ²
Spraying Temperatures of bitumen: 150-200°C	

J-6-3 Hand tools and equipment

The types of tools and equipment that are essential for the construction of the Penetration Macadam surface when using a labour-based approach are listed below. The numbers of each item required will depend on the size of the construction project.

Manpower	Tools and Equipment
• 1 supervisor • 1 work gang for hauling and spreading aggregate • 1 heating bitumen workers • 1-2 hand spray bitumen operator • 2-4 workers for hauling heated bitumen • 1 roller operator.	• Brooms • String line, pegs • Wheel barrows • Steel pegs and string line, 5 m and 30 m measuring tapes • Bitumen tanker and distributor or bucket for spraying bitumen • Pickaxes. • Shovels • Hoes. • Rakes. • measuring can • Roller of minimum capacity 6 Tonns • Air compressor.

J-6-4 Quality control for construction of prime coat and penetration macadam

The construction of Prime coat and Penetration Macadam (Pen-Mac) activities include selection and test of material, heat and spray bitumen, spreading aggregate and compaction. Quality control and test for these works include checking the suitability of the material, grading of the material, check application rate of spraying bitumen and spread rate of aggregate of each layer. Some test can be carried out in the field and some test should be done in laboratory if required by a client.

<i>Description/ work activity</i>	<i>Test/check method</i>	<i>When</i>	<i>Tools</i>
Material for Prime coat and Pen-Mac			
Aggregate: Purity +grading	✓ Take a sample from a crusher for the testing. ✓ conduct grading test of difference size aggregate: sieve analyse(refer to specification) ✓ visual check of cleanness: free from soil, dust, tree root, tree branch or leaves	Before procurement	LAB
Bitumen	✓ visual check type (penetration grade) refer to specification ✓ if the dump is leakage	Before procurement	NA
Kerosin for cutback	✓ visual check of purity of the kerosin for producing the cutback	Before procurement	NA
Construction of Prime coat and Pen-Mac			
Prime coat	✓ visual check of base course layer are clean ✓ check if pegs and string line are used for every 10 m interval at both edges of the road to control area of spraying the prime coat ✓ check heating temperature of bitumen (refer to specification) ✓ check mixing rate of heated bitumen with kerosin (30-40% of kerosin) ✓ check spraying rate i.e. measure cutback use and divide with road area covered.	During carrying out the activity	Thermometer
Pen-Mac	✓ visual check peg and string line are set for every 10 m interval at both edges of the road at area to cover the Pen-Mac ✓ check difference sizes of aggregates if they are enough ie. calculating quantity compares to area of road to cover the Pen-Mac ✓ check if the bitumen are delivered on the quantity and type refers to specification ✓ check the heating operator and bitumen sprayer are equipped with safety gears	Before commencing the Pen-Mac activity.	Measuring tape
	✓ check heating temperature of the bitumen as required(normally 150-200 °C) or refers to the specification. ✓ check spreading rate for each layer of the	During carrying out the Pen-Mac	Measuring tape and thermometer

	- heated bitumen i.e calculating the quantity of bitumen compares to area to be sprayed. ✓ check the spread rate of crushed aggregate of each layer .i.e. calculating quantity of the aggregate compares to area to be spread. check the aggregate of each layer are spread uniformly. ✓ randomly count number of passes of compaction for each layer ✓ ensuring all three layers of the Pen-Mac are completed within a maximum of 2 to 3 days.	activity	
Final check	✓ all remained material include empty bitumen drums are cleared from site ✓ check area was used for heating the bitumen are restored and holes for heating bitumen are filled and levelled	After completion of the work	NA

J-6-5 Health and safety for bitumen work

All the pavement surfaces described in this module involve the use of bituminous binders during construction. Depending on the particular surfaces or the availability of binder, they may be hot bitumen or bituminous emulsions.

Emulsions that can be sprayed at low to medium temperature and only need slight heating in a mobile heater tank are most suitable for labour-based methods. There is no evidence to suggest serious health hazards are associated with the use of bitumen emulsions. However, repeated or prolonged skin contact should be avoided to minimize the chance of skin irritation . Contact with skin can be avoided by the wearing of protective clothing, rubber gloves and boots. At the end of the working day, the workforce should thoroughly wash exposed skin with soap and water. The wearing of goggles will protect eyes but where eyes are accidentally splashed, they should be flushed with large amounts of water and medical help sought.

The use of hot bitumen can present hazards for the labour forces. Generally, heating of bitumen should be carried out in a purpose made towable heater tank typically fitted with a spray bar or hand lance for labour-based work. A hazard is the risk of burns to exposed skin. Burns should be immediately drenched with cold water for at least 10 minutes or until cool. In many cases heating of bitumen is done by making a fire under a drum containing the bitumen and then carry the heated bitumen manually in locally made spraying buckets. This method of heating the bitumen poses a lot of risks during heating, carrying and spraying the heated bitumen. To minimize the risk, protective heat resistant gloves, masks and footwear should be worn.

It is essential for the safety and health of the workforce that good working practices are observed at all times. The operators of equipment such as heating, bitumen spraying operator and hand sprayers must be fully trained and familiar with their use.

J-7 Construction of plum concrete surface

Concrete pavements provides a strong and rigid surface and are common in a number of countries, in particular for roads with high traffic densities or roads in very steep terrain. They are built either with or without reinforcement. For rural roads the concrete pavement surface is usually built without reinforcement as traffic volumes generally are low and to minimize the construction cost.



Plum concrete surface is one concrete surfacing option which is suitable for rural roads that often do not have high volumes of traffic but may have steep gradients and where gravel surfacing would not be suitable due to heavy gravel loss. The plum concrete pavement is a mix of concrete and larger solid stones, where the volume of stones typically 30-40% reduces the volume of concrete needed, which usually reduces the costs but still provides a strong and durable pavement.

The plum concrete surfacing layer should be place on a prepared road sub-base (sub-base for low traffic density road). The work comprises of preparing road base (or sub base), mixing of plum concrete, hauling and placing the concrete on a prepared road base (or sub base). The mixing of the Plum concrete in accordance to mixing proportion determined by engineer and specified in the specification. The construction of the plum concrete pavement usually starts with a 5 cm layer of lean concrete, which is placed directly on the road sub-base. Strong stones 7-10 cm are placed on the lean concrete with some 5 cm spacing. A 12 cm thick concrete layer is constructed on top of the lean concrete. The concrete is poured in between and over the stones making sure to cover the stones with at least 2 cm.

J-7-1 Material

Same as other concrete works, material for the plum concrete surface consists of cement, aggregate, large stone and water.

Cement

Cement also known as Ordinary Portland Cement (OPC) is produced from limestone and clay. The cement is usually used for this purpose delivered in paper bags containing of 40 kg or 50 kg each.

Aggregates

Aggregate for mixing the plum concrete can be natural aggregate from river or crushed aggregate from stone. Size of the aggregate can be varied that provides more dense and make concrete stronger. The required grading of the aggregate is specified in the drawing or technical specification. However the maximum size of the aggregate should not be greater than 50mm.

Natural gravel and sand very often contain impurities, such as clay, silt, humus, leaves and grass. It is important to work with clean aggregates and wash if necessary

before mixing the concrete. The aggregates for the plum concrete works should be well graded. If the batch of aggregate contains a large percentage of flat or flaky particles it should be rejected.

Sand

Sand is used as void filler in the mix and also to reduce friction between the stone particles. Like other concrete work, the sand for mixing the plum concrete must be clean, free of leaves, grass, compost, clay lumps, or dust etc. Sand should be fairly coarse clean river sand. River sand may need to be sieved before used to remove stones and dust. Often the best sand is a mixture of river sand and pit sand.

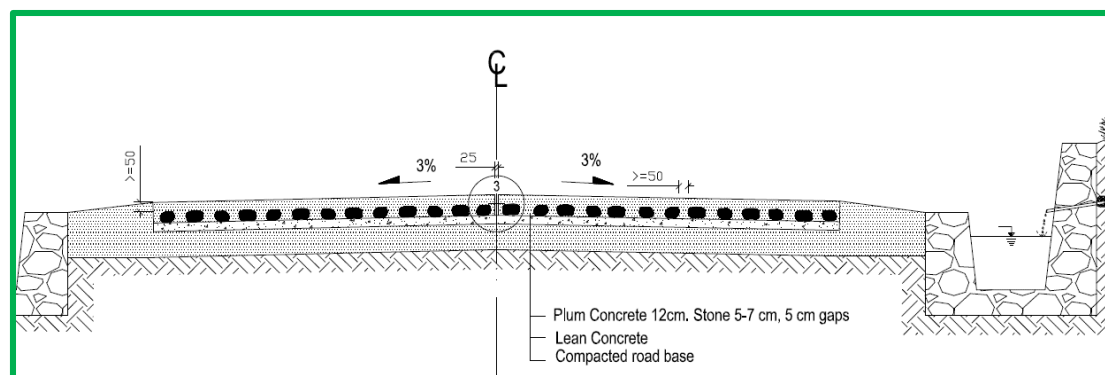
Water

Water is used for mixing and curing concrete. Water is used to activate the cement and wet the sand and aggregates during the concrete mixing. The water for this purpose must be clean. Impurities in the water affect quality of the plum concrete. The water can be taken from rivers, lakes, wells or taps. Sea water, surface run-off water, dirty water with organic particle must not be used. Dirty water can be put in a drum and can be used after the dirt or organic particles have settled at the bottom of the drum.

Large stones

The large stones to be used for plum concrete work must be clean, hard, durable, solid and free from soft material or loose piece. Cracked and hollow stones should not be used. Stones can be chosen round or cubic shaped. The stone should not be cracked under impact or compaction equipment or crack when dropped three times onto a hard rock surface from shoulder height. Size of the stone shall be used is specified on the drawings otherwise the maximum dimension of the stone shall not be greater than thickness of designed slab. Generally size the large stones used for the plum concrete should be 7-10 cm

J-7-2 Work method



The plum concrete surface should be constructed in block of maximum 5 meters in length and width should be half of the road width. As the concrete work is poured in-situ on the work site, it is important to keep traffic open during the construction period. Therefore the concrete work should normally be done for half of the width of the road and keep the other side open for traffic. The steps of the construction of each block should be done as follows:

Step 1

Setting out and place form works (edge supports). Before placing formwork to ensure that the road base is well compacted, clean, free from soft material. Cleaning the road base should use broom.

The formwork should be fixed in place in half width of the road and to the designed height (about 17 cm). Level of the formwork at the center line must be higher than the edge support placed at the edge (shoulder) with 2-% of cross fall. Line level should be used to transfer level on top of the formwork from road center line to edge of the road. Size of each box should be: width= half width of the road, and Length= 3 to 5m. The formwork, once removed will provide a 5-10 mm gap in between the boxes which will serve as expansion joints.



Step 2

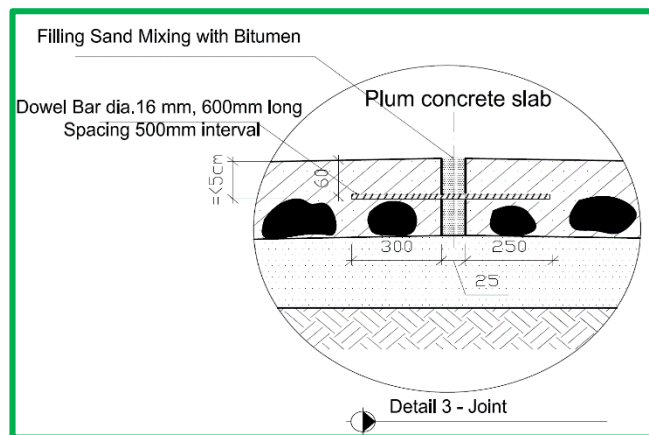
Mix and place lean concrete on the prepared road sub base inside the form work. Mixing lean concrete should follow the mixing procedure and normal practice. The lean concrete should be mixed by a concrete mixer with mixing proportion as specified in the drawing or technical specifications. The mixing proportion for lean concrete is normally 1:3:6.

Pour the lean concrete of a thickness as specified in the drawing or technical specifications, generally the thickness of the lean concrete is 5 cm. The large stones (plums) shall then be laid on the lean concrete while the lean is still within the initial setting time. But, the concrete should then be sufficiently stiff enough to prevent complete submergence of the stones. The bottom part of the stones (about 1/3 of stone thickness) should be embedded in the concrete and the remaining part exposed so as to form a key with the next layer of concrete. The plums (large stones) should be placed with gaps between them of no less than 50 mm.



Step 3

Once the large stones (plums) are placed, concrete for the last layer shall be mixed and placed following normal practice with the mixing proportion as specified in the drawings or technical specifications. The mixing proportion for the last layer should be 1:2:4. The concrete should be poured between the formworks and around the large stones until it is 2 cm above with the top of the stones and then compacted until no more air is removed. Normally the total volume of plums should not exceed 40% of the volume of the finished concrete.



Step 4

Curing: The concrete should be protected from traffic for minimum 2 days, after which the formwork (edge supports) can be removed, and should be cured for minimum 7 days. The curing shall commence 3-4 hours after placing the concrete. The curing process is most critical during the initial days after pouring. It is necessary to keep the concrete surfaces continuously wet during the curing period.

The principal of curing can be achieved by:

- ✓ sprinkling water on concrete surface, taking care to keep a permanent wet surface,
- ✓ covering the concrete surface with either empty cement bags, or sand or sawdust (minimum 5 cm layer), wet jute, dust or banana leaves. These covers must also be kept continuously wet,
- ✓ make a pond of water on the concrete. This can be used on large, flat surfaces such as slabs,

Once the first half of the plum concrete surface curing have achieved the minimum required strength, it can be opened for traffic while the second half of the road can be constructed following the steps as described for construction of first half of the road.



J-7-3 Quality control for construction of plum concrete surface

The construction of Plum concrete surface activity includes selection and test of material, mix, place and cure the concrete. Quality control and test for these works include checking the suitability of the material. Some test can be carried out in the field and some test should be done in laboratory if required by a client.

Description/ work activity	Test/check method	When	Tools
Material plum concrete			
Aggregate, sand, cement and water	✓ refer to quality control of material as mentioned in quality for concrete work		
Stone	✓ Hardness, shape, strength, durable refer to quality control as mentioned in quality control for stone masonry work ✓ size of stone: visual check and randomly dimension check as size refer to specification	Before procurement of the stone	Measuring tape
Construction of plum concrete			
Placing formwork/edge support	✓ visual check sub base layer is compacted, cleaned and levelled ✓ dimension check width, high and level (camber) of the box	Before the start of mixing concrete	Measuring tape and line level
Lean Concrete for bedding	✓ mix and place concrete refer to quality control mentioned in quality control for concrete work dimension check thickness of the concrete	During carrying out lean concrete activity	Measuring tape
Placing stone, mixing and pouring concrete	✓ Placing large stone ✓ gap between each stone should not less than 5 cm ✓ no stone are place overlapping each other ✓ top level of the large stone not higher than level of edge support ✓ Concrete work ✓ prepare 3 concrete cubs for strength testing ✓ mix and place concrete refer to quality control mentioned in quality control for concrete work. ✓ check the concrete fill all gaps of the large stone and well compacted ✓ check thickness of the concrete refer to specification ✓ check on evenly surface. the surface should be scratched for roughness	During carrying out the concrete work	Measuring tape and Lab
curing	✓ keep wet: to cover by bag or sand and continue adding water	always for min. 14 days	NA
Final check for finishing work	✓ Visual check: ✓ all remaining material has been cleared from site ✓ formwork is removed after min. 14 days and taken away from site	After completion of the work	NA

J-8 Stone surface

The stone surface option can be used for rural road construction where there are medium to high traffic densities or where sections of the road have steep longitudinal gradients. Stone surfacing may also provide appropriate surface treatments for road sections through rural villages and communities as well as market places. The stone surface can be produced using the natural shape of the stone and placing it by hand in its tightest possible positions by minimizing the size of the joints. The joint will then be filled by smaller stone. The stone surface can also be produced by cutting stone into cubic or rectangular shapes in order to ensure that they are placed a tight pattern. Cutting (or dressing) stones in this way mean the final surface will be smoother than the stone using natural shape.



In both options the stones are laid on a prepared road sub base with a layer of sand cushion about 5 cm in between the stones and the road sub base layers. The sand cushion is accommodating irregularities of the stones allowing the stones to be assembled with a smooth and level riding surface. The sand cushion layer is also acting as a drainage for any water entering between the stones. The stone surface will then cover by a layer of gravel filling gaps between the stones and providing a smoother surface for traffic. The stone surface option can be acting as road base course layer for Penetration Macadam..

J-8-2 Material

Material for constructing the stone surface consists of coarse sand, stone and gravel. The minimum required characteristic of the material are described below:

Stones

The stone to be used for the pavement must be clean, hard, durable, solid and free from soft material or loose pieces.

Cracked and hollow stones must not be used. Stones should be cubic or rectangular in shape. The stone should not be cracked under impact of compaction equipment.



Round shape stone or river stones are not recommended for this purpose. The size of the stones may vary depending on the functions of the stones or otherwise specified in the drawings. Recommended size and shape of the stones to use for the stone surface are:

- ✚ Stone for surface should be 15 cm x 25 cm, with the smallest acceptable size 10 cm x 15 cm. Stones should be cubic or rectangular shaped. If the stone from a quarry should be dressed or shaped to get the required shape.
- ✚ Stones for kerb should ideally be 20 cm x 30 cm with the smallest acceptable size 15 cm x 25 cm. The kerbstones should be cubic or rectangular shaped. If the stone from a quarry should be dressed or shape. The kerb stone is crucial to hold the other stones in place.
- ✚ Small stones for filling the gaps should be 2 cm x 3 cm and 3 cm x 5 cm

Sand

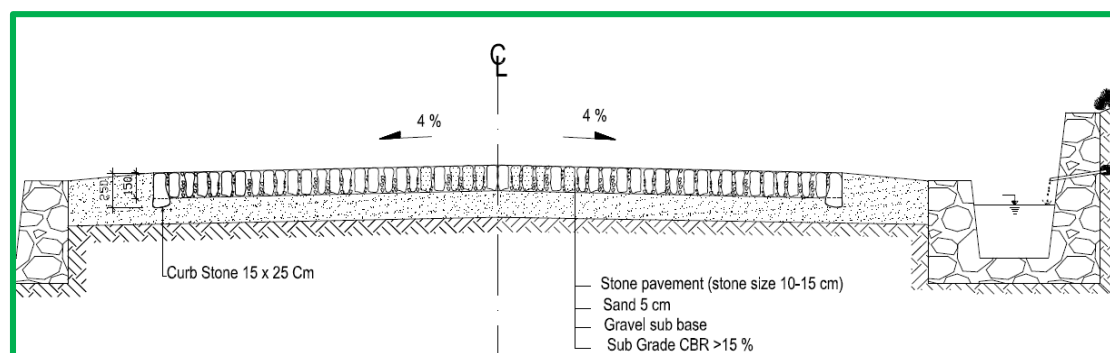
Sand for the stone surface is used to accommodate any irregularities in the shape of the stones allowing the stones to be assembled with a smooth and level riding surface. The sand is also used as a drainage for any water entering between the stones. The sand should be coarse sand either from river or mountain sand and must be clean, free of leaves, grass, compost, clay lumps, or dust etc.

Gravel

The gavel is used to fill gaps between stones to retain the stones movement while traffics over the surface. The gravel is also acting to provide smooth surface of the final layer. The gravel is laid over the stone surface and will fill the gaps. The gravel for this purpose can be mountain gravel or river gravel and should contains difference grading. The size of the gravel should not be greater than 50 mm and must be clean, free of leaves, grass, compost, clay lumps etc.

J-8-3 Work method

Step 1 Setting out road cross section by set center line peg and pegs at edge of the carriageway. The cross section should be set for every 5 m interval. Mark top level of the stone surface at the center line and transfer to level to the edge pegs. The difference in level from the center line to the edge pegs should be 4-5%

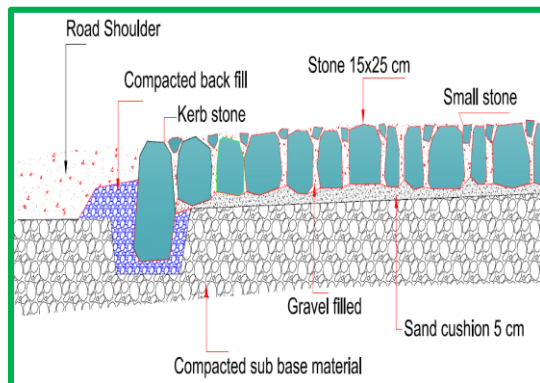


Excavate foundation for Kerbstones. The foundation should be excavated along road edges. The width of the foundation should be 25-30 cm and depth should be 15-20

cm. Bed level of the foundation of both edge should be checked using line level to ensure they are at the same level.

Place Kerbstones in the excavated foundation in vertical position by keeping top level of the stone as set in the peg. The kerbstones should be placed as tight as possible. Back fill the kerbstones by gravel and provide compaction by hand rammer. Repeat the same process of placing kerbstones to other edge of the road.

Step 2 Prepare road sub base by shaping the sub base to level and ensuring 3-5% camber. Compact the prepared sub base by hand rammer then place and spread coarse sand of 5 cm thickness.



Step 3 String line is tighten at the marked level connect from edge pegs and center line pegs. Place the stones on the spread sand as close together as possible. Some stones are slightly wedge-shape and it is necessary to place the wider end down onto the sand layer. The stones should be placed from edge toward center line of the road. Ensure the top level of the stones is at the level set by the string line. Where ever the top level of the stone are higher than the set string line, such stones should be hammered down into the sand to get level. After the large stones are placed it is important to use small stones tighten the stones by inserting the small stones into gaps between the large stones. The layer of the stones surface is demanding skilled labour to achieve good workmanship.

Step 4 To avoid movement of the stone, a thin layer of sand is spread over the stone surface and washed into the voids by water.



In order to prevent stone surface from penetrating water and to provide smoother surface for vehicles, the stone paving should be covered by a thin layer of 5 cm of selected gravel. The selected gravel should contain mixture of clay portion, sand and

coarse aggregate of grading not larger than 50 mm. The selected gravel is spread on the stone surface. Some portions of the gravel will then be filled the stones gaps to strengthen the stability of the stones and other remain on the surface.

After spreading the selected gravel, final compaction will be carried out, by 2-3 passes using a 3-5 tonnes rollers. Vibration during the compaction should not be used for this purpose. The compaction will level the height of the stones providing smoother surface on the carriage way. The compaction should be carried out from road edge toward center line of the road

Step 5 constructing road shoulders

Road shoulders shall be filled by using mountain gravel or laterite. Before filling, the existing shoulder should be wet by water. The shoulders is filled and spread to the same level of the kerbstones. The filled material is spread to form a slope of 7-8% toward outside of the road. Compaction is then carried out by vibrating pedestrian roller or plate compactor/vibrating tamper.



Step 6 constructing filter drains

Filter drain is constructed to drain water from the stone surface. The filter drains are provided at interval 5 - 10 m for both side of road shoulder. The filter drains should be constructed at the time of filling road shoulders by excavating the drain cross the road shoulders in rectangular shape of 20-30 cm wide and bottom level of the drain should be same as bottom level of the kerbstone and slightly slope toward outside the road. The excavated rectangular box is filled by Broken stone and top level should be over by same material of the road shoulders. Compaction can be commenced at the time of compacting for road shoulders.

Step 7

The road shoulders and slopes should be protected from erosion by planting grass. The roots of the grass can help to retain the soil and stabilise the slopes and shoulders by preventing the soil from being washed away.

J-8-3 Quality control for construction of stone surface

The construction of stone surface activity includes selection and test of material, prepare and place stone. Quality control and test for these works include checking the suitable of the material. Some test can be carried out in the field and some test should be done in laboratory if required by a client.

<i>Description/ work activity</i>	<i>Test/check method</i>	<i>When</i>	<i>Tools</i>
Material stone surface			
Gravel and sand	✓ Quality of gravel refers to quality control of gravel surface ✓ Quality of sand refers to quality control of material for concrete work.	Before delivery on site	NA
Stone for surface kerbstone	✓ Hardness, shape, strength, durable refer to quality control as mentioned in quality control for stone masonry work ✓ size of stone: visual check and randomly dimension check as size refer to specification	Before procurement of the stone	Measuring tape
Construction of stone surface			
Placing kerbstone	✓ check pegs and string line are used at edges of carriage way for every 5 m interval ✓ check width and depth of the foundation for placing kerbstone according to drawing ✓ check the kerbstones are placed vertically and close to each other as possible	During carrying out kerbstone activity	Measuring tape
Placing stone surface	✓ visual check sub base layer is compacted, cleaned and levelled ✓ check thickness of sand for bedding and uniformly spread ✓ check the stones are shaped (slightly dressed) for cubic or rectangular shape. size should be between 12 cm - 20 cm: ✓ check stones are placed close each other as possible. ✓ gaps are filled by smaller stone ✓ tope level should be evenly laid ✓ all the gaps between each stone are fully filled by sand	After placing kerbstone	Measuring tape and line level
Spread gravel	✓ check thickness of gravel laid on surface ✓ randomly count passes of compaction	After placing stone surface	Measuring tape
Construction shoulders and filter drain	✓ check material for filter drain in accordance to specification ✓ dimension check width and location of the filter drain ✓ check quality of material used for shoulder as per specification ✓ level of the shoulder should be same as tope level of kerbstone and slope toward the side drain ✓ compaction degree of the shoulder by randomly count number of passes during compaction	During construction of shoulders	Measuring tape
Final check for finishing work	✓ Visual check: ✓ all remaining material has been cleared from site ✓ holes or side barrow are filled and level	After completion of the work	N/A

J-9 Safety and health for construction of road base course, bituminous surface, concrete and stone surface

This includes the provision of general safety and health measures for labourers on site for the construction of road base course, bituminous surface, concrete and stone surfaces.

J-9-1 Safety Measures

-  Carry out a safety briefing for all workers before works begin. Make sure work is organized so that each worker has enough space to carry out his or her task without endangering to workers.
-  Place warning signs or cones at each end of the work area. The warning signs should be placed 50-100 m away from the working areas. The text on the warning signs should read: "KUIDADU" or " HALAI NENEIK"
-  All equipment operators must be trained in the use of their equipment (trucks, rollers, mixers, bitumen sprayer etc). Equipment must be in good condition and safety covers for moving parts should be used.
-  No children are allowed enter in the work area.
-  The contractor shall not allow the use of alcohol or drugs on the works site or in the site camp.

J-9-2 Drinking water:

Drinking water must be available within 50 metres of all work sites approximately 2 litres should be available per worker per day

J-9-3 Safety Gear:

All workers and operators must be explained clearly of any potential danger of various work activities and what precautions to take to avoid any accidents on site. All workers and operators shall be provided appropriate safety gear in sufficient numbers. All workers must be instructed how and when to use safety gear and items shall replaced when unusable or lost: The Contractor shall provide safety gear as listed below.

-  Safety jackets in bright colours for supervisors and for all workers if working on a road that has frequent traffic
-  Closed shoes and gloves for all workers for general road works. Note that cotton gloves need to be replaced regularly
-  Gum boots and good quality gloves when carrying concrete work and working on bitumen works
-  Dust masks when working with bitumen activities. Note that dust masks must be replaced regularly

J-9-4 First Aid:

A first aid box must be provided on site and must be regularly checked and restocked.

LBT Training Manual

Module K

Concrete & Stone masonry

Table of Contents, Module K Concrete & Stone Masonry

K-1	Concrete.....	3
K-1-1	Material for concrete.....	3
K-1-2	Types of concrete	5
K-1-3	Mixing concrete	5
K-1-4	Transporting concrete	9
K-1-5	Placing concrete	9
K-1-6	Compaction of concrete	9
K-1-7	Curing concrete	10
K-1-8	Slump test.....	11
K-1-9	Quality Control for concrete works	12
K-2	Stone masonry	13
K-2-1	Material for stone masonry works	13
K-2-2	Mortar for stone masonry works.....	13
K-2-3	Joint and bond for stone masonry works	14
K-2-4	Weep holes	16
K-2-5	Quality control for Stone masonry work	16

K-1 Concrete

In rural road works, concrete is used for drainage structures such as culverts, bridges, drifts, lined drains and some time also used for paving the road surface at critical section. Concrete is a mixture of cement, water, sand and stone. It normally sets within 1/2 hour to 1 hour and starts to harden after 2 hours. It rapidly gains strength from the initial day and continue even after 28 days. At 28 days the strength achieved is approximately 90% (the usual period after which strength testing is carried out).

K-1-1 Material for concrete

Cement

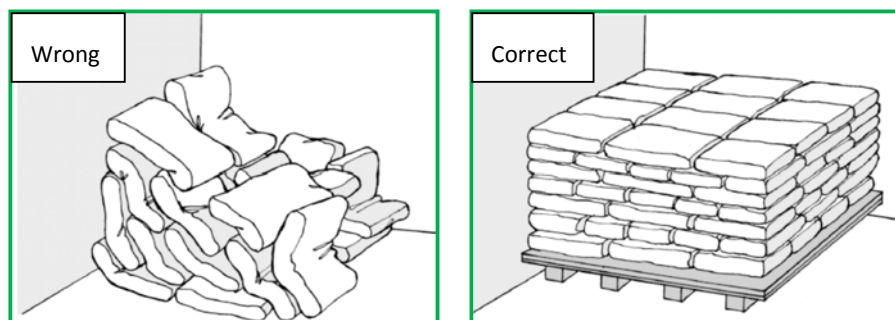
Cement also known as Ordinary Portland Cement (OPC) is produced from limestone and clay. These materials are burnt at high temperatures to form cement clinker. A small quantity of gypsum is added to the cooled clinker to control the rate of setting. The clinker is then ground to a fine powder to produce Portland cement. Cement is usually delivered in paper bags containing of 40 kg or 50 kg each.

Handling and Storing cement

Cement must be very careful handled to avoid breakage. Off loading of the cement should be done by hand to keep the paper bags unbroken.

Cement should be stored as follows:

- ✚ Cement must be stored off ground in a shaded and well ventilated dry place
- ✚ Tarpaulins or other imperious coverings should not be used as they allow moisture to collect on the underside.
- ✚ Bags must be stocked not more than above man height to avoid compaction of lower bags.
- ✚ Should be used rotation first stocked-first used
- ✚ Stock bags close together, but keep a clear space between the bags and the walls.
- ✚ *Hardened lumps found in the bag after opening should be removed by sieving the cement.*



Aggregates

Aggregate for mixing the concrete can be natural aggregate and crushed aggregate from stone. Size of the aggregate can be varied that provides more dense and make concrete stronger.

The aggregates are "fine" and "coarse". Fine aggregate is sand up to 2mm and coarse aggregates are stones from 2mm up to 50mm. If sand is not easily available quarry dust can be used instead.

Natural gravel and sand very often contain impurities, such as clay, silt, humus, leaves and grass. It is important to work with clean aggregates and wash if necessary before mixing the concrete. The aggregates for the concrete works should be well graded. If the batch of aggregate contains a large percentage of flat or flaky particles it should be rejected.

Storage aggregates

On site aggregate should be deposited on clean ground (no dirt and no topsoil). Stockpiles of aggregates should not be placed under trees as leaves and seeds will contaminate the aggregates. Aggregates of different sizes should be stored in separate heaps to avoid uncontrolled mixing. Sand should be covered by tarpaulin to avoid the fine particle being washed by rain during rainy season, and rain water should drain away from stockpiles.

Sand

Sand is the **fine aggregate** used in concrete. Sand is used as void filler in the mix and also to reduce friction between the stone particles. If the sand consists of round particles that are smooth, the mix will flow easily and have good workability. If the particles of sand are flat as well as rough textured, the mix will be harsh and the workability poor. To improve workability, more water and more cement is required if the strength is to be maintained. This means increased cost.

The sand for mixing the concrete must be clean, free of leaves, grass, compost, clay lumps, or dust etc. Sand should be fairly coarse clean river sand. River sand may need to be sieved before used to remove stones and dust. Often the best sand is a mixture of river sand and pit sand. Sand should be stored as storing the aggregate mentioned above.

Water

Water is used for mixing and curing concrete. Water is used to activate the cement and wet the sand and aggregates during the concrete mixing. The water for this purpose must be clean. Impurities in the water affect quality of the concrete. The water can be taken from rivers, lakes, wells or taps. Sea water, surface run-off water, dirty water with organic particle must not be used. Dirty water can be put in a drum and can be used after the dirt or organic particles have settled at the bottom of the drum.

K-1-2 Types of concrete

The proportion of the mix affects the quality and strength of the concrete and varies therefore depending its intended use. For labour-based road works the three following types are usually used.

Type and description	Mix (proportion) Cement:Sand :Stone	Use
Lean concrete This is a meagre mix with low cement content, stiff and not too wet.	1 : 4 : 8	• blind for foundation excavation, • bedding of culvert, bridge, drift, • other works where required little strength
Mass concrete This type of concrete has a medium strength. This concrete appropriate for structures where reinforcing steel is not used. A large sized stone (up to 50 mm) is therefore permitted. Larger stones would create mixing difficulties. The cement content is higher than in the lean concrete but lower than for structural concrete. The grade indicates the required strength of 15N/mm ² after 28 days.	1 : 3 : 6	• non reinforced structures • culvert packing • kerb stone placing • concrete building blocks • etc...
Structural concrete This type of concrete is intended for use in reinforced structures and load bearing applications. It has a high cement content and a higher strength of the lean concrete and mass concrete. This type of concrete is used for reinforced concrete. The maximum aggregate size is normally 20 mm to allow the concrete to easily pass around steel reinforcement. The grade indicates the required strength of 20-25 N/mm ² after 28 days.	1 : 2 : 4	• reinforced structures • reinforced and unreinforced culverts • under water reinforced or unreinforced concrete • any concrete with reinforced steel

Note that there are higher classes of concrete (30 and 40) that are used in special cases. These are not normally required for rural road site works.

K-1-3 Mixing concrete

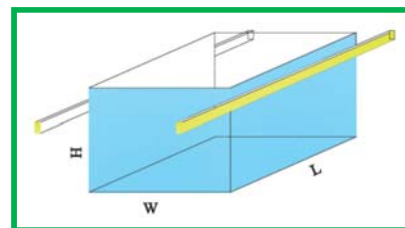
Concrete can be mixed by hand or by mechanical means. Concrete on a labour-based sites is usually mixed by hand and where available with a concrete mixer.

The components for the mix are usually measured by volume. In order to achieve the required mix proportions and to estimate quantity of each material **gauge boxes** are

used to batch, or measure volumes of the material, to control the mix proportions. The Gauge box should be prepared based on quantity of 1 bag of cement.

Table below shows size of gouge box:

For cement 1 bag= 50 kg	For cement 1 bag= 40 kg
W= 30 cm	W= 30 cm
H= 30 cm	H= 30 cm
L= 40 cm	L= 32 cm
Volume= 0.036 m ³	Volume= 0.029 m ³



The gauge box must be filled level with the top so that the volume of the sand and stone measured out is equal to the volume of a bag of cement. The sand and stone in the gauge box must not be compacted when filled up.

Mixing by volume

Table below shows material for mixing concrete of 1 m³

Concrete		Material required for 1 m³ of concrete			
<i>Mix</i>	<i>Class</i>	<i>Cement (kg)</i>	<i>Sand (m³)</i>	<i>Stone (m³)</i>	<i>Max. size of stone (mm)</i>
1:4:8	Lean (C10)	166	0.47	0.94	40
1:3:6	Mass (C15)	215	0.46	0.92	50
1:2:4	Structural (C20)	300	0.42	0.84	20
1:1.5:3	Structural (C25)	365	0.38	0.76	20

Table below shows material required for mixing concrete based on 1 bag of cement

Concrete Mix	Batch with 1 bag of cement=50kg		Batch with 1 bag of cement=40kg	
	<i>No of gauge boxes (size: 30 cm x 30cm x 40cm)</i>		<i>No of gauge boxes (size: 30 cm x 30cm x 32cm)</i>	
	<i>Sand</i>	<i>Stone</i>	<i>Sand</i>	<i>Stone</i>
1:4:8	4	8	4	8
1:3:6	3	6	3	6
1:2:4	2	4	2	4
1:1.5:3	1.5	3	1.5	3

Water cement ratio

The amount of clean water used for mixing the concrete affects the strength of the concrete. The amount of water should be the minimum necessary to give sufficient workability, ideally the mix should be at the optimum moisture content. Higher amount of water will weaken the strength of the concrete. The amount of water for mixing concrete is specified by weight and stated as a fraction or ratio of cement used. Weight of water divided by weight of cement = water/cement ratio.

A water/cement ratio of 0.5 is good for the mixing the concrete. If a bag of cement contains 50 kg, then 25 liters of water should be used for the mix. If a bag of cement contains 40 kg, then 20 litres of water should be used for the mix. If sand and aggregates are wet, the amount of water should be reduced accordingly.

Generally every litre of water added in addition reduces the strength of the concrete equivalent to 2 - 3 kgs of cement. Therefore, ***as a rule the drier the mix the stronger the concrete.***

When using mechanical mixing the amount of water can be lower between 22 - 26 litres for a bag of cement = 50 kgs. When mixing manually the amount of water can be higher between 24-26 liters for 1 bag of cement = 50 kgs.

A simple hand test helps to determine whether the mix has the right consistency and water content.

- ✚ Pick a handful of ready mixed concrete and form a ball in your hand. If this is not possible, then the mix is too wet.
- ✚ If possible to form a ball in your hand, drop the ball onto a hard surface...if the ball totally collapses, then the mix is too dry

Hand mixing concrete

Hand mixed batches should not exceed 0.5m³. The mixing should never be done on the bare ground, as this results in contamination of the mix. A platform should be prepared prior to commencing the mixing of concrete. The platform can be built with timber boards or lean concrete on the ground. The platform should be enough to mix 0.5 m³ of concrete.

Mixing procedures

- ✚ Measure the amount of sand and stones with the gauge box and put them in alternating layers on the platform and mix thoroughly by turning the heap over several times.
- ✚ The most effective way is to mix with 2 people facing each other and work from opposition sides of the heap.

- ✚ Add cement on top of the well mixed heap of sand and stone
- ✚ The dry materials are mixed until the colour of the mix is uniform.
- ✚ Water is then added by a third person while turning the mix using a garden watering can or sprinkled from a bucket so that the water is spread evenly while the material is mixed again. Only the correct amount of water should be added. The mixing must continue until the concrete is uniformly wet and has reached the required consistency.

Mechanical mixing concrete

Mixing concrete mechanically with a powered concrete mixer can produce a more homogeneous and better mix. The quantities of the component for the mix depend on type of the concrete mixture. It is important to bear in mind that the volume of the material for the mix should not be more than $\frac{2}{3}$ of the volume of the mixing drum.



Mixing using the Concrete Mixer

The following procedure is recommended when using powered concrete mixers:

- ✚ pour some of the water into the mixer to clean the drum walls of any concrete left from the previous mix;
- ✚ load half of the prescribed amount of aggregate. The aggregate will also assist in cleaning the inner surfaces of the drum;
- ✚ add the required amount of sand;
- ✚ add the cement and continue dry mix for one minute;
- ✚ when the aggregate and the cement have been thoroughly mixed, add the remaining quantity of aggregate and then add water and mix wet for another two minutes. Usually between 1.5 to 3 minutes is sufficient to obtain a good mixture. Mixing more than 3 minutes will not improve the quality of the mixture.
- ✚ The mixer must be cleaned at the end of the day or when the mixing operation is interrupted for a long time. This can be done by charging (loading) the mixer with a small quantity of aggregate and water, mixing for a while and then discharging the cleaning material.

K-1-4 Transporting concrete

Concrete should be mixed as near as possible to the site of placement. The wet concrete should be transported quickly to allow placement before setting commences.

For the Labour based road works, transportation by wheel is commonly used. The following points require attention when concrete is transported:

- ✚ Concrete should be placed as soon as possible after mixing. If delays in placing concrete do occur, then concrete that is transported in open wheelbarrows should be covered with plastic sheets or tarpaulins to reduce drying out.
- ✚ Leaking wheelbarrows should **not** be used for transporting concrete as loss of concrete fines may occur.
- ✚ Concrete should not become diluted with water. Rain water in wheelbarrows should be emptied out before fresh concrete is placed in them. Similarly, fresh concrete should not be allowed to stand in heavy rain unless it is well covered with plastic sheets or tarpaulins.

K-1-5 Placing concrete

Concrete should be placed in position as soon as possible before setting has begun. This allows a **maximum of 15 minutes** after mixing to transport and place the concrete.

The formwork for the concrete must be clean, secure from movement or leakage and should be wetted before the concrete is placed. Placing concrete starts from the corners of the formwork and as closely as possible to its final position.

For walls, concrete has to be placed in layers not exceeding 30cm when compacted by hand with a hand rammer and 60cm when a vibrating poker is used. Each layer must be rammed or vibrated before the next is spread. As a rule of thumb, sufficient compaction is achieved when water appears on the surface and/or drips through the joints of the framework, provided that the water/cement ration is correct and the formwork has been constructed with tied joints. Care should be taken to avoid that wet mix falls outside the formworks.

Slabs and floors should be poured in one continuous operation to avoid any vertical or horizontal joints. The top of the concrete should be finish smoothly with a masons trowel. Any cold joints should be left rough to ensure a good bond for the next layer of the concrete.

K-1-6 Compaction of concrete

Concrete must be properly compacted to remove all the air voids trapped in it. Compaction should start immediately after placing the concrete. There are several methods of compacting concrete but the most common in road works are:

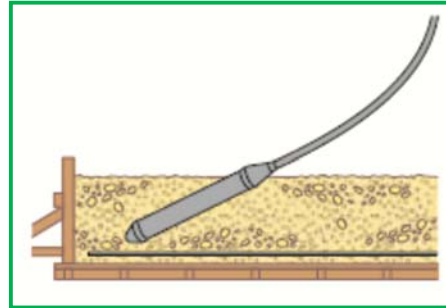
- ✚ Hand compaction (hand ramming) and
- ✚ Mechanical vibration (poker vibrator)

Hand compaction

Hand compaction is normally used for concrete in wall foundations, unreinforced slabs and blinding layers. Suitable pieces of timber or steel rod are normally used to compact the concrete. For ground slabs like aprons the screed board is also used to compact the concrete.

Mechanical compaction

Mechanical compaction is the most effective method to achieve high quality and strength. Internal vibration using a poker vibrator is the most common equipment for this method of compacting concrete. To ensure good compaction, the following points are important:



Concrete should be placed in layers not deeper than 30 cm and each layer should be vibrated before the next layer is placed. The poker should be pushed vertically into the concrete as quickly as possible of about 50 cm apart. The poker should be withdrawn slowly from the concrete to avoid leaving behind a void. When water wells up to the surface it is slowly taken out. Vibration should not be longer than 10 seconds in one place and the vibrator should be kept away from the formwork and reinforcement bars.

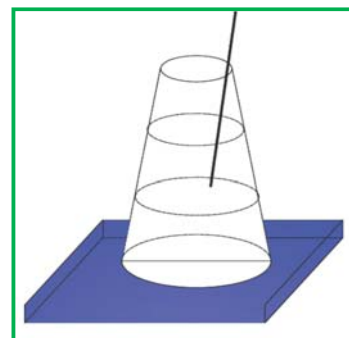
K-1-7 Curing concrete

The concrete must be cured with water to prevent the concrete drying out during the settling and hardening stage. The curing must commence after 3-4 hours after placing the concrete. The curing process is most critical during the initial days after pouring. If the concrete is allowed to dry out too soon, the results could include cracking, unsatisfactory strength and poor durability. It is necessary to keep the concrete surfaces continuously wet for at least 7 days (and if possible 14 days).



The principal of curing can be achieved by:

- ✚ sprinkling water on concrete surface, taking care to keep a permanent wet surface,
- ✚ covering the concrete surface with either empty cement bags, or sand or sawdust (minimum 5 cm layer), wet jute, dust or banana leaves. These covers must also be kept continuously wet,



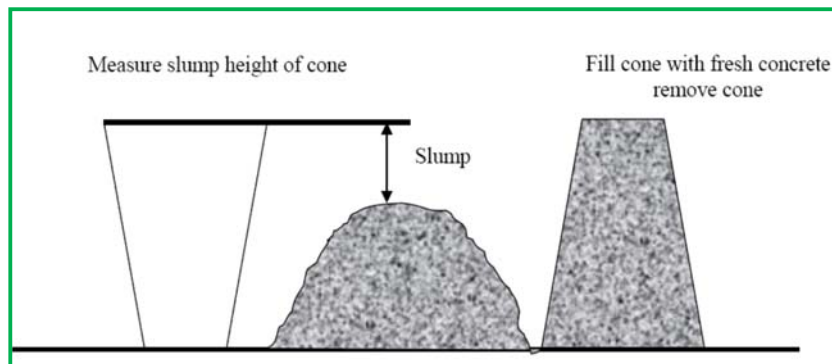
- ✚ wooden formwork for walls can be loosened a bit, left in place and regularly flooded with water,
- ✚ make a pond of water on the concrete. This can be used on large, flat surfaces such as slabs,
- ✚ ponding should not be used for concrete cast on the ground as it may cause softening of the ground under the joints.

K-1-8 Slump test

During mixing of concrete it is important to make sure the water content is sufficient to make the fresh concrete workable. The workability and the amount of water in a fresh concrete mix can be assessed using the slump test, in which a sample of the mix is shaped in a standard form.

Apparatus for slump testing:

- ✚ Slump cone, 300 mm high;
- ✚ Tamping rod, 16 mm diameter, 600 mm long;
- ✚ Flat floor or base plate. Can be wooden platform or concrete floor



Work method

- ✚ Place the slump cone vertically on a prepared platform or prepared surface by the large end of the cone place down.
- ✚ Fill fresh concrete in the cone with concrete in 4 layers each about 75 mm high. Compact each layer with 25 strokes of the rounded end of the tamping bar.
- ✚ When full and compacted, the cone is then lifted straight off and placed back on the ground next to the test material
- ✚ Place the tamping bar across the cone and measure the slump to the centre of the top surface of the concrete. and measure the slump.
- ✚ When the slump is within a range of 50 to 125 mm the concrete is regarded as having an acceptable consistency and water content for structure works. If the slump is less than 50 mm, the concrete may be too stiff and not sufficiently

workable. Equally, if the high of the slump is more than 125 mm indicate water content is too high so should reduce water for mixing the concrete.

K-1-9 Quality Control for concrete works

Quality control for the concrete involves checking the suitability of the material used for the concrete making and the strength of the cured concrete. Some test shall be carried out in a Laboratory whilst other simple tests can be carried out on site. The Site Engineer/Supervisor has to ensure on site that the quality meets the required specifications. The Site Engineer/Supervisor must control the mixing and curing continuously and perform simple site tests as mentioned below to ensure good quality work. The quality control shall be carried out in daily basis by contractor's site staff and the Client assigned staff.

Test Item	Test/check method	When	Tools
Material for concrete			
Sand: purity and grading	✓ Visual	before procurement	NA
Aggregate: purity + grading	✓ Visual: if requested grading should be conducted in a Lab.	before procurement	NA-LAB
Water: purity	✓ visual, must be fresh water without contamination. if requested conduct Lab-test	always	NA
Cement: age and condition	✓ production date ✓ visual inspection make sure cement bag is not leaking, no lumps or hardened cement in the bag	when buying and using, particularly after storage	NA
Production of concrete			
Mixing (batching): Place	✓ visual: as near to the structure as possible. If mixing on the ground make sure the surface is clean and not contaminating the mix	before project start	NA
Identification: concrete type	✓ check specifications	for every concrete job	NA
Batching volumes	✓ box 32x30x30cm (for cement 40kg bag)	Before mixing concrete	Measuring tap
Mixing arrangements	✓ counting batches and water	always	NA
Mixture: consistency and plasticity	✓ concrete should be workable but not too wet ✓ slump test. Slump should be: ✓ for concrete structure: 50-125mm. for sub structure and mass concrete: 25-100mm ✓ hand moulding,	During trial mixing for every concrete job	Slump cone, measuring tape and mould
Casting time limit	✓ 1 hour	always	NA
Compaction (vibration)	✓ Visual check ✓ fill layers of max. 30cm height ✓ cement milk passing joints	Entire period of concrete casting	NA
Curing	✓ keep wet	always for min. 15 days	NA

Concrete strength test: for major concrete work.	✓ Fill concrete in mould(cubic or cylinder). Min. 3 samples for each structure. and cure in water for 28 days	Fill the mould during casting concrete	Cubic or cylinder Mould
	✓ Hammer test	After 28 days	Concrete test hammer

K-2 Stone masonry

In labour-based road rehabilitation, the stone masonry works provide important function for drainage structures like: culverts, drifts, bridge abutments and wing walls and retaining walls. This module provides some basic guidelines for implementing the stone masonry works.

The stone masonry guidelines in this module apply to minor drainage structure works while the major structure works may require further specifications.

K-2-1 Material for stone masonry works

Sand

Sand must be taken from places where the quality is good. The quality of river sand varies, depending whether it is dug from the inside or outside of a bend or from a straight part of the river. Sand for this purpose must be clean free from dust, clay, vegetation, rout, organize material etc.

Stone

Stone to be used for this purpose should be clean, hard and solid. Cracked and hollow stones should not be used. Stones should be chosen as close to rectangular shape as possible. Before using the stone must be washed and free from dust and dirt.

Cement and water

Same as apply to the requirement of mixing concrete.

K-2-2 Mortar for stone masonry works

Mortar for the stone masonry work is a mixture of cement, sand and water. The strength of the mortar is depends on quantity of the cement. Proportion of the mortar varies from one to other type of structures. It is normally in the range from 1:4 to 1:7 (cement:sand).

Mortar should be mixed thoroughly. Mix sand and cement before adding water. Quantity of water for mixing should be in between 0.4-0.5 ratio of water/cement. The quantity of mortar to be mixed should not be more than a mason can use within 1 hour to avoid the mortar harden.

Table below shows recommended mixing proportion of mortar for different types of structures

Type of structure	Mixture (cement : sand)	Note
Stone linings, minor walls, not bearing walls	1:7	Always check in the contract specification or consult with the engineer in charge when in doubt
Small retaining walls, head walls and wing walls up to 1 m high	1:6	
Bearing walls, walls for structures, retaining walls higher than 1 m	1:4	

A simple way of checking that the correct water/cement ratio for the mortar is used is to take the fresh mortar and knead in your hand. If the kneaded mortar cannot be formed or cannot stick together, then the mortar is too dry and water needs to be added. If the kneaded mortar leaks between the fingers, then too much water has been used. If the kneaded mortar retains its form then the correct ratio has been achieved.

K-2-3 Joint and bond for stone masonry works

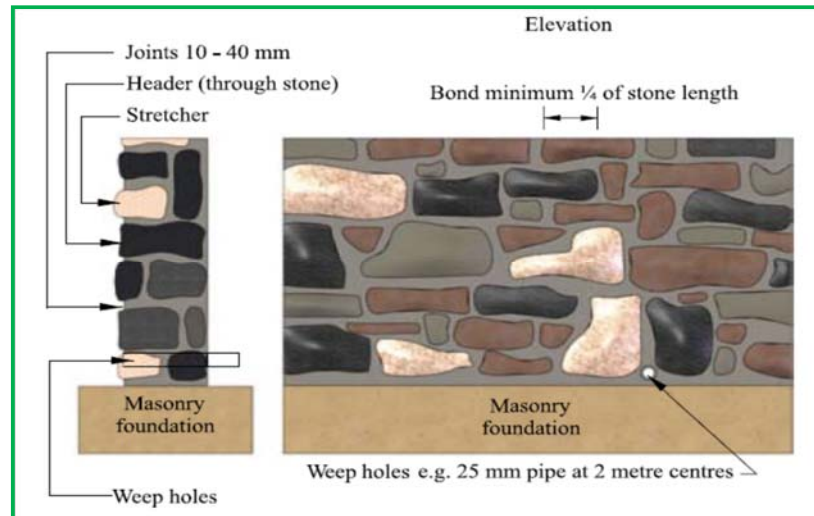
Joint

The material quantities for the stone masonry work depends on shape of the stone to be used.

The space from one pieces of stone to another must be filled by mortar, called "Joint". Thickness of the joint varies between 1 cm to 4 cm depending on the shape of the stone. If the stone is shaped as a rectangular prism the thickness of the join should be from 1 cm to 2.5 cm, if the stone is not shaped the thickness of the joint will be from 1 cm to 4 cm. ***The surface of the stone must not be touch each other without mortar but should be fully laid into the mortar.***

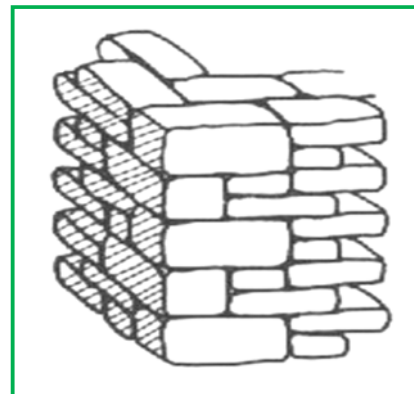
Table below shows quantity mortar to be used for different type of stone

Masonry type	Approximate width of joints	Required material for 1 m ³ of finished wall	
		Stone	Mortar
Rubble stone masonry. The stones are not specifically cut or shaped	1 cm to 4 cm	1.3 m ³ -1.5 m ³	0.3 m ³ -0.4 m ³
Shaped stone masonry. The stones are shaped to rectangular prism	1 cm to 2.5 cm	1.2 m ³	0.2 m ³ -0.3 m ³



Bond

When placing stones for the stone masonry work, they should overlap from one layer of stones to another layer. The overlap of the stone should be $\frac{1}{4}$ length of the smaller stone. Most of the stones are laid as stretcher. Headers, or through stones, should be laid at regular intervals to bond the two faces of the wall together. The bond stones should cover at least $\frac{2}{3}$ of the wall thickness and overlap should not be less than 10cm.



Foundations

Foundation for the stone masonry work must be excavated until reaching firm soil or the designed depth specified by the design engineer. The excavated footing should be compacted before placing the stone masonry foundation. If soil is not firm, the best solution is a wide foundation on a well-compacted footing. In this case the engineer must approve the footing before masonry is laid.

For minor walls up to 1.5 m in height, which do not support heavy weight, no special concrete foundation is needed however, the required size of the foundation is:

- ✚ Minimum dept of the foundation = wall thickness and not less than 40 cm
- ✚ Minimum width of the foundation= 2 x wall thickness
- ✚ Lean concrete for the foundation 5 cm
- ✚ The first course should be laid using the largest stone and straightest stones.

- The mortar used for a foundation must be strong and resistant to water. The mix used should be 1:4 (1 cement: 4 sand)

*Note that foundations for **bearing walls** are usually reinforced concrete and need to be appropriately designed by the engineer*

K-2-4 Weep holes

Retaining walls of stone masonry must have weep holes. The weep holes should be installed above ground level and water level. Weep holes can prevent water pressure from building up behind the wall and allows water gathered to drain out through the hole. For minor walls, the diameter of the weep hole should be between 2-5 cm.



K-2-5 Quality control for Stone masonry work

Quality control for stone masonry involves the checking of the suitability and strength of the material used, the strength of the cured stone masonry work and the workmanship. The tests and checking should be carried out by the Site engineer/Supervisor to ensure on site that the quality meets the required specifications. The quality control shall be carried out in daily basis by contractor's field staff and the Client assigned field staff.

Test Item/work activities		Test/check method	When	Tools
Material for stone masonry				
Stone	Hardness or strength	✓ Hammer ring test or drop test	Before procurement of the stone	NA
	Shape	✓ Visual(should be angular or cubic and rough and flat surface. Face should be broken rather than smooth)		
	Size	✓ Visual(most stone should be 15 to 30 cm + some small stone of size 5 cm. width > 1/3 of height)		
	Durable	✓ Visual (No crack or break)		
Mortar		✓ Perform test as refers to Quality Control for Mortar		
Construction of Stone masonry				
Excavation trench for foundation:		✓ ensure pegs and string lines are used for every mix. 10m interval. ✓ dimension check width and depth of the trench, including sufficient space to	During carrying out the activity	Measuring tap

	construct the masonry works ✓ bedding must be placed on firm soil and at the designed level		
Mixing mortar	✓ Perform the test refer to quality control of Mortar	During mixing mortar activity	As mentioned in Mortar control
Setting out	✓ Visual check: ✓ ensure pegs and string line(double string with 10cm space) are used for every mix. 5m. ✓ dimension check, width and height	Before commencing masonry work	Measuring tap
Laying stone	✓ Visual check: ✓ laying stone: large stone place at bottom and corner of the wall. flat surface side face to out side of the wall. ✓ stone to be wet before placing ✓ all gaps are filled with mortar. ensuring proper bonding join (thickness of mortar joint 2 - 5 cm) ✓ check on evenly surface and pointing of the stone masonry work.	During carrying out masonry work	Measuring tap
Curing	✓ keep wet: to cover by bag or sand and continue adding water	always for min. 7 days	NA

LBT Training Manual

Module L

Culvert, lined drain, drift & Gabion

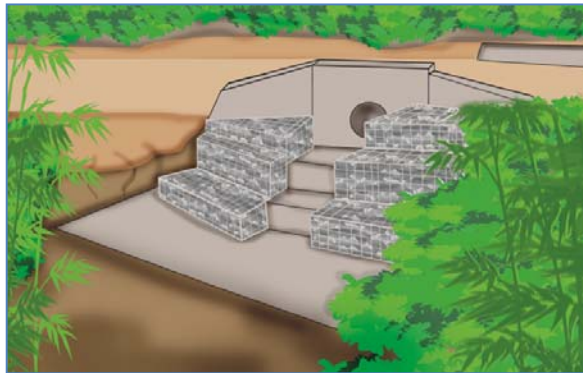
Table of Contents, Module L Culverts

L-1	Culverts	3
L-1-1	Introduction	3
L-1-2	Typical Culvert Features.	4
L-1-3	Culvert Location.....	5
L-1-4	Positioning of a culvert	5
L-1-5	Setting out	5
L-1-6	Construction of box culvert	8
L-1-7	Quality control for Construction of box culvert	18
L-2	Stone masonry lined side drains	20
L-2-1	Introduction	20
L-2-2	Construction material.....	20
L-2-3	Tools and equipment:.....	20
L-2-4	Work Method	21
L-2-5	Quality control for construction of stone masonry lined drain	23
L-3	Drift	24
L-3-1	General Introduction	24
L-3-2	Selection location for a drift	24
L-3-3	Main features of a drift	25
L-3-4	Design considerations for the drifts	26
L-3-5	Construction	27
L-3-6	Quality control for drift Construction.....	31
L-4	Gabion works	32
L-4-1	Construction of gabion structures.....	32
L-4-2	Quality Control For Gabion works	34
L-5	Safety and health for drainage structures and erosion protection works	35

L-1 Culverts

L-1-1 Introduction

Culverts play a very important role of the drainage system to lead water from the road. Culverts allows water to cross underneath the road and lead water from uphill side of the road to the lower side where it can be safely charged. Road construction may obstruct the natural flow of water unless the crossroad drainage is properly designed and provided.



The water may be flowing from natural streams or run-off surface water from the road structure or areas close to the road. There are basically two types of culverts, depending on their function:

- ✚ **Relief culvert:** is an integrated part of the road drainage system, and conveys water from the upper side of the road to the lower side. It discharges runoff water during and after rainfall from the road surface, side drains and adjacent roadside areas. Relief culverts carry water seasonally only.
- ✚ **Stream culvert:** is required at the intersection point between an existing water course and road alignment. The stream culvert allows water from streams, rivers or canals to cross beneath the road. The volume of water to be discharged through the culvert includes the flood carried by stream or river and runoff water from the road drainage system.

Culverts can be built using different materials, including brick and stone masonry, corrugated steel, timber and concrete. Culverts are also constructed in a wide range of shapes and sizes. There are several types of culverts that can be constructed based on available construction material, skills of masons and volume of water to be discharged, etc. These most common types of culverts are:

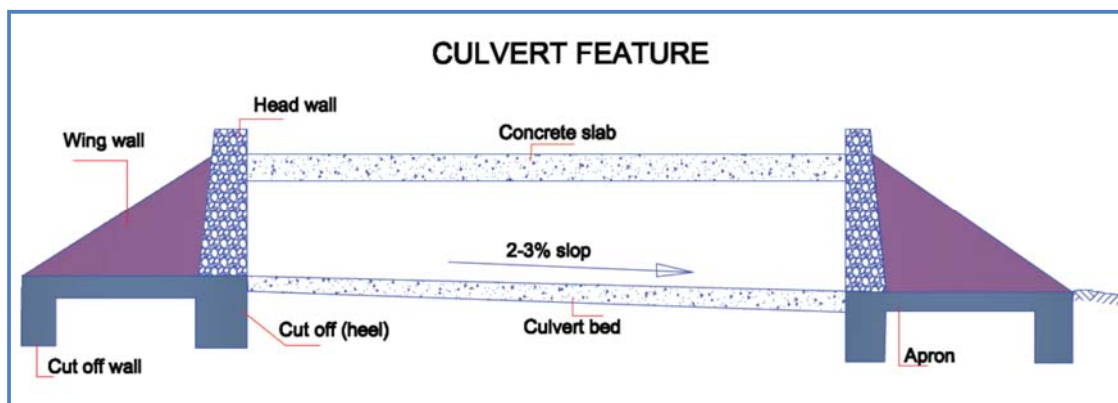
- ✚ **Concrete pipe culvert:** They can be manufactured on site or purchased from suppliers. The most common size used for rural roads is the pipe culvert with a diameter of 60 cm made from concrete. Note that pipe culvert can also be made from corrugated metal. Any smaller diameter should be avoided as they may be difficult to clean and maintain. Larger diameters of concrete pipes need to be reinforced and require a thicker layer of fill over the rings. A large size culvert can be replaced with two or more rows of a smaller dimension.
- ✚ **Reinforced Concrete box culvert:** Rectangular shaped culverts – referred to as reinforced concrete box culverts - are commonly used to cater for larger crossings.
- ✚ **Box culvert** refer to the mix of stone masonry for abutment walls, wing walls and aprons with reinforced concrete slab. This culvert is commonly used to catch

smaller crossing river or relief culvert. This design is suitable where stones for the masonry work are readily available and is commonly used in Timor Leste.



L-1-2 Typical Culvert Features.

This module describes the construction of box culvert made from stone masonry abutment walls, wing walls and apron with a reinforced concrete slab.



The main features of the box culvert are:

- ✓ Stone masonry head wall
- ✓ Stone masonry wing walls
- ✓ Stone masonry aprons and cut off walls
- ✓ Stone masonry abutment walls
- ✓ Stone masonry bedding
- ✓ Reinforced concrete slab

L-1-3 Culvert Location

The location of culverts should be determined during the road condition survey. The final location of the culvert should be agreed during construction. It is important to identify all locations where the culverts are needed along the road that is being rehabilitated. The following are signs that a culvert is needed or an existing culvert needs to be replaced:

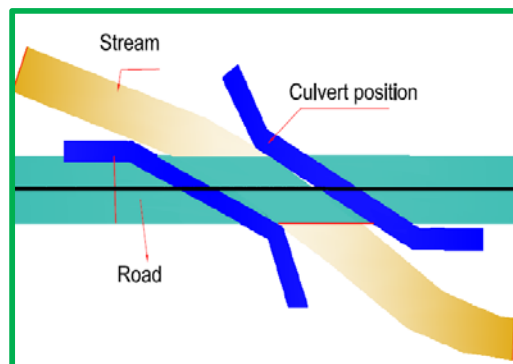
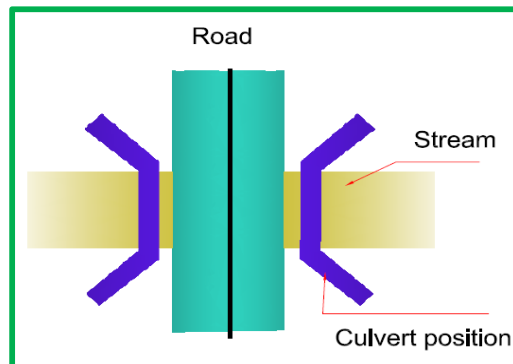
- ✚ small gullies have formed because water has been flowing across the road,
- ✚ sand has deposited on the road because of standing water, or
- ✚ because they have carried too much water.

Careful consideration should be given to how and where the water is discharged. Water collected along the road and discharged through a culvert may cause serious soil erosion and damage to the surrounding downstream areas.

L-1-4 Positioning of a culvert

The position of a culvert is a critical. A culvert should be positioned as close as possible to the direction of the natural flow of the stream or river. Positioning of culverts should be in the following manner:

- ✚ **For relief culvert:** A relief culvert should be perpendicular to the road alignment. Therefore the centerline of the culvert should be 90° to the road centerline.
- ✚ **For stream culvert:** A stream culvert should follow the alignment of the stream.



L-1-5 Setting out

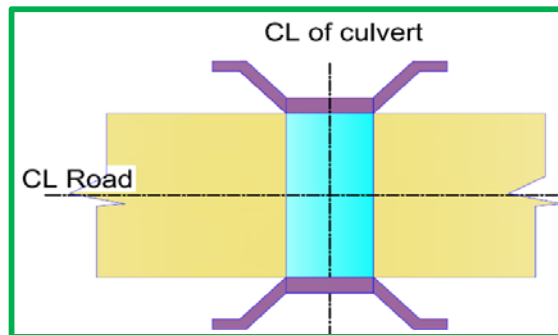
The position, gradient and dimension for a culvert can be established with simple setting out methods using simple setting out tools as shown in table below:

- ✓ 3 ranging rods
- ✓ 3 profile boards
- ✓ 1 line level or hose pipe
- ✓ 50 m string line
- ✓ 20 pegs - 40 cm long
- ✓ 2 offset pegs - 1 to 1.5 m long
- ✓ 1 hammer
- ✓ 1 permanent marker
- ✓ 1 measuring tape 20 m
- ✓ 1 measuring tape 5 m

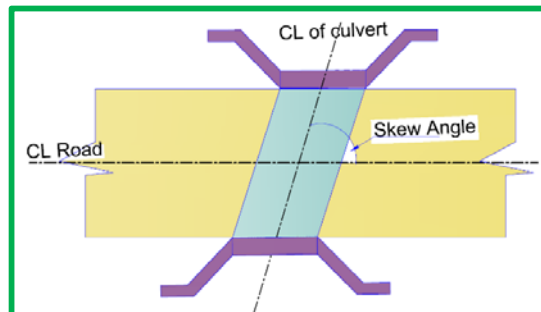
Setting out position of culvert (culvert centerline)

Once the location of the culvert has been finally agreed, it is important to establish center line for the culvert.

✚ For relief culvert, the centerline should be perpendicular to the road center line. This process can follow the setting out 90° process (like method 3-4-5 as described in the setting out module). Once the center line of the culvert is established, two wooden pegs are set as reference at the inlet and outlet of the culvert. To facilitate the construction works additional two Offset pegs should be set 2-3m away from the inlet and outlet pegs. These offset pegs will help keep and indicate information during construction such as level of foundation, level of bedding, abutment height level and centerline of the culvert



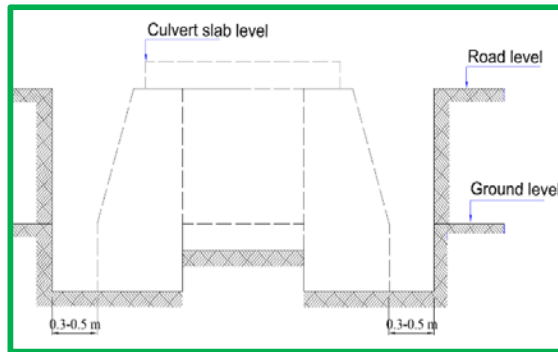
✚ For a stream culvert, the centerline of the culvert should be aligned to the stream flow direction. The center line of this culvert depends on the direction of the flow crossing the road. This centerline can some time be perpendicular to the road center line but some time also skewed to the road center line.



Once the alignment of the stream is identified two wooden pegs should be set at inlet and outlet of the culvert. It is recommended to also to establish two off set pegs as above mentioned.

Setting out width of the culvert

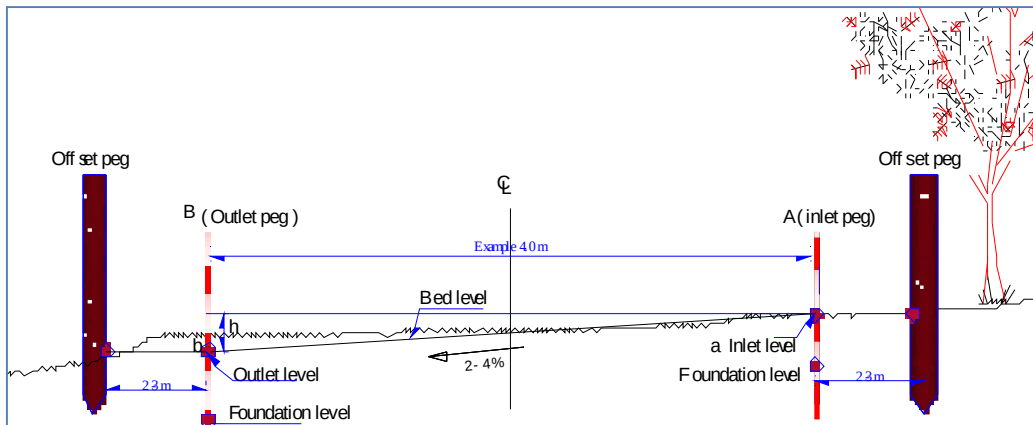
Set out trench for the width of the culvert. The trench should be wide enough to allow workers to comfortably carry out the construction of the abutment. A clearance of at least 30 - 40 cm on each side of the intended width of the abutments. The width of the trench should be measured from center line of the culvert.



The purpose of adding an extra width of 30-40 cm on each side of the abutment is to keep sufficient space for compacting the fill material with hand rammers or hand tamper.

Setting out level of outlet and inlet for a culvert

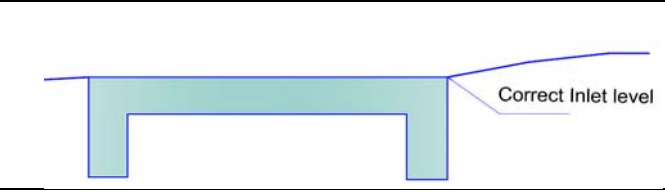
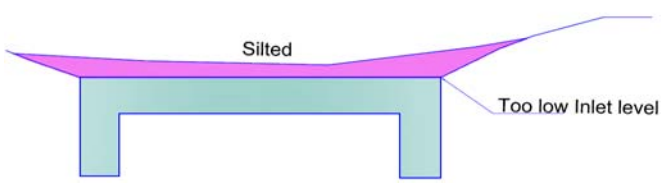
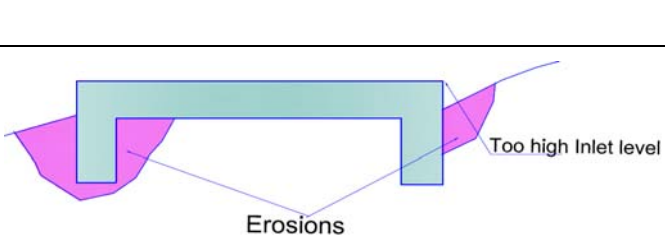
The gradient of bed level of the culvert should be 2-4 % in order to allow water flow through the culvert, washing out any deposits to reduce future maintenance requirements. When determining the level of the culvert, also ensure that there is a sufficient slope at downstream of the culvert. The following steps should be follow for setting out inlet and outlet of the culvert:



- Step 1. Set pegs A at inlet and peg B at outlet. Determine inlet level. The inlet level should be the same level of stream bed. For the relief culvert the inlet level should be at the level of side drain or otherwise should be fixed by the engineer. The inlet level should be set after excavation of trench. Once the inlet level is identified mark the inlet level as (a). The level (a) is transferred to offset pegs by line level .
- Step 2. Set outlet level: Transfer the level (a) to Peg B by using line level then deduct 2-4%. This level represents level (b). Transfer level (b) to Offset peg (B)

Example: the distance between peg A and peg B = 4 m and the slope is 3%.
 The difference in level (h) of A and B is therefore $h = 4\text{m} \times 3/100 = 0.12\text{m}$. So
 the outlet level (b) should be marked 0.12m lower than (a)

Attention should be made when setting out inlet and outlet levels. The Table below shows the correct and incorrect of inlet levels. The outlet level will depend on the inlet level as described in the example above.

Note: Attention should be cared for setting out inlet and out let level.	
Inlet level of a culvert should be set same level of stream bed.	
If the inlet of the culvert is lower than the invert of the centre line of the streambed – resulting in the silting of the barrel of the culvert.	
If the inlet of the culvert is higher than river bed level – resulting in erosion on the outfall and inlet.	

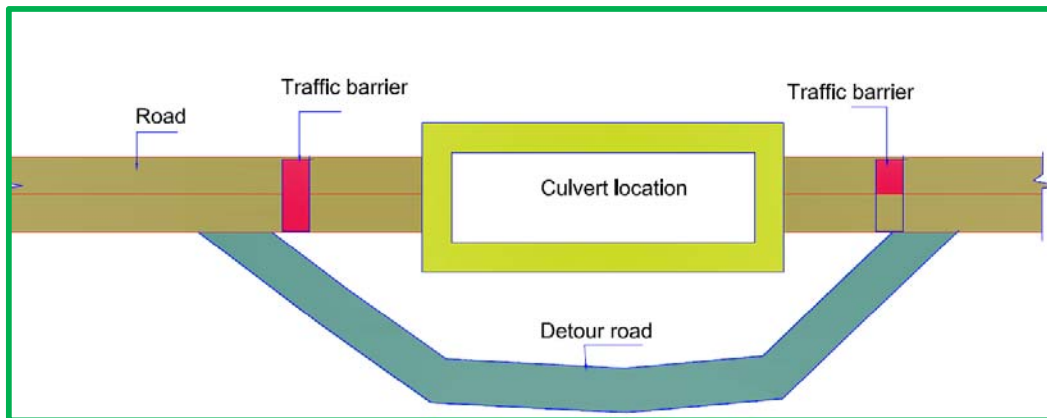
L-1-6 Construction of box culvert

(refers to stone masonry wing walls, abutment walls and reinforcement slab)

This type of box culverts are commonly built in Timor-Leste. In Timor-Leste this design is more practical and the most economical choice as stone and sand for the construction can easily be found on site and local masonry workers are familiar with the works. This culvert type is good for where the volume of water is moderate. The stone masonry box culvert should be constructed in-situ and is easily constructed by a small group of people consisting of 1-2 skilled workers (masons) and 3-5 unskilled assistants. The sequence of the construction activities include:



Step 1 Prepare a detour road

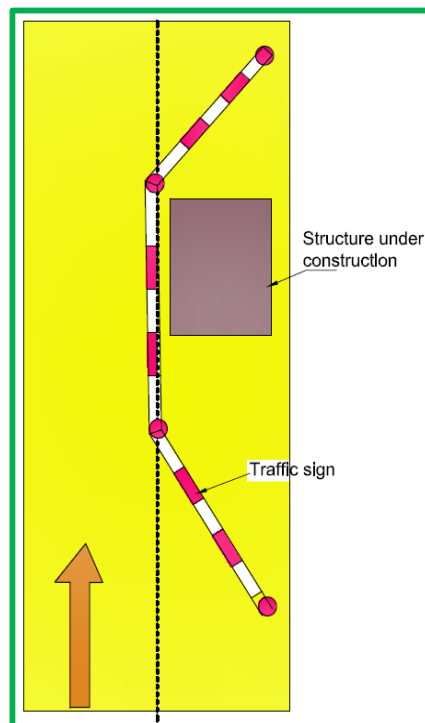


Prior to starting excavation of foundation for a culvert or prior to demolishing any existing drainage structure, a detour road should be constructed to divert the flow of traffic from the working place during the construction work. It is important to keep traffic open at all times during the construction of the drainage structure and is usually a contractual obligation.

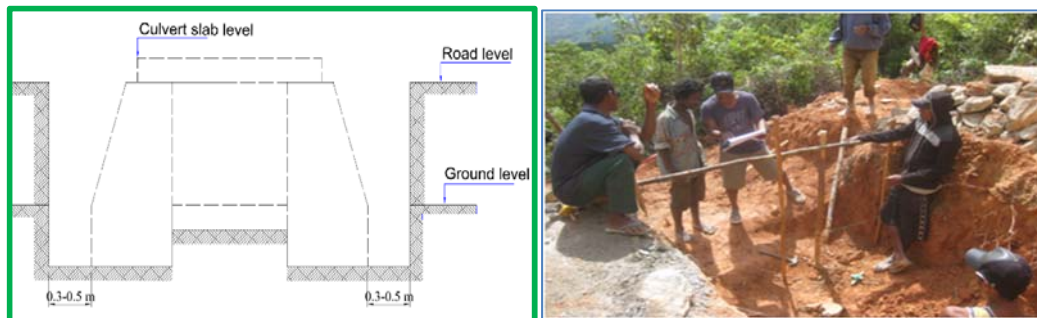
If it is not possible to build a detour outside the culvert site, the alternative is to build one half of the culvert while allowing traffic to pass on the other half of the roadway.

The detour can be constructed by building up the embankment to above water level. The width of the detour road should be sufficient to safely allow trucks and other vehicles to pass over the temporarily filled area. A gravel layer should be provided for surface. The embankment should have a function as dam to protect water flow through the construction place and the flow of traffic.

In order to keep the work site dry and free from water, it may be necessary to build temporary waterways. In many cases a temporary cross drainage can be provided under the embankment to allow of water flow across under the detour road. In such cases concrete pipes or corrugated metal culvert pipes need to be installed before filling the embankment.



Step 2 Excavation of foundation and prepare bedding for the culvert



- ✚ Set out centerline of the culvert and place reference points (off set) by wooden pegs or concrete poles at the inlet and outlet
- ✚ Set out and place pegs for trench excavation for the foundation. The width for the trench should be wider than the intended width of the abutment of 30-40 cm on both sides.
- ✚ Excavation of the trench for foundation. The dept of the trench should be as specified on the drawings ensuring that the foundation is constructed on firm soil . If the depth of the excavation is greater than 2 m then the sides of the trench must be sloped 2:1 (height : width) to avoid collapse of the walls, or it may be necessary to support the trench walls with temporary retaining walls (wooden walls) to prevent collapse of the walls. In order to keep the work site dry and free from water, it may be necessary to build temporary waterways.
- ✚ Before commencing the stone masonry work, a bedding should be prepared by removing all loose soil and replace muddy soil with suitable gravel and compact with plate vibrator or hand tamp.
- ✚ Once the bedding is leveled and well compacted a layer of lean concrete for about 5 cm thick is poured on the bed before commencing stone masonry abutment wall.

Attention: When excavating deep trenches it is important to take necessary precautions. Walls should be sloped to avoid collapse and potentially burying workers inside digging the trench and it is also important to make sure no one falls in. A clearly marked barrier should be placed around the trench.

Step 3 Construction of stone masonry for wing walls, aprons and abutment wall

Construction material

The wing walls, aprons and abutment walls are constructed from cement stone masonry, therefore materials required for the stone masonry are: Large stones, sand, cement and water. The required characteristic of the material is described in Module K for the construction of stone masonry chapter.

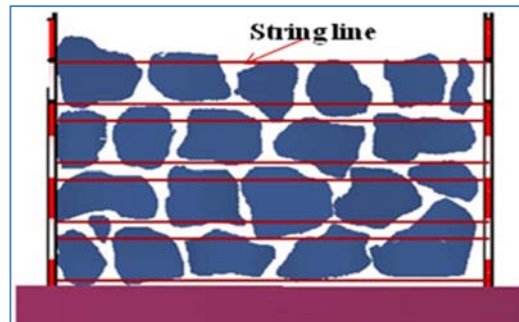
Tools and equipment

The following plant, tools and equipment are recommended for the construction of stone masonry wing walls, abutment walls and aprons by using labour-based approach:

Steel or wooden pegs	Measuring tape 3 m or 5 m
Hammer	Steel and/or timber shutters/formwork
Line level	Concrete mixer for mixing concrete and mortar (hand mixing is acceptable for mortar mixing)
Profile boards and ranging rods	200 litres drums for storing water
Pick axes and shovel	Screed
Wheelbarrows	Trowels
Hand tamper or hand rammer	
Buckets	

Work methods for construction of abutment walls

The abutment walls are constructed to support the top slab of the culvert and to prevent soil erosion. The abutment walls can be constructed from concrete or stone masonry and gabions. For smaller box culverts the abutment walls can be built from stone masonry. This module describes the construction of abutment walls for a culvert using cement stone masonry. The following steps are:



Setting out for the abutment walls

- ✓ Set out correct length of the abutment walls and place pegs at the inlet and out let. Then measure from culvert center line and set desired inner width of the culvert.

- ✓ Set out outer pegs for thickness of the abutment walls at the inlet and outlet points of the culvert. The thickness of the abutment walls should be as shown on the drawing.
- ✓ Mark the desired height of the abutment walls at the inner peg. This level should be the level of the bottom slab of the culvert. Transfer this level to other 3 pegs using a line level then mark the level on those pegs. Transfer the top abutment level to Offset pegs.
- ✓ Use string line to guide construction of the stone masonry works. Two strings should be tied in parallel lines with a spacing of between 10 to 15 cm. Both string lines will be moved upwards to follow the progress of laying the stone masonry work. String lines should be set out to follow the inner and outer edges of the abutment walls.

Stone masonry work for the abutment walls.

- ✓ Mix and place lean concrete of 5 cm at the bed of the abutment walls. Mixing proportion for the lean concrete should 1:3:6,
- ✓ Construct the abutment walls. The construction technique for stone masonry is described in Module K for the construction of stone masonry chapter.
- ✓ Provide weep holes for every 0.5-0.7 m along the abutment walls. Diameter for the weep holes should be 5-7 cm.
- ✓ The finished stone masonry work should be cured immediately after the mortar has started to harden by application of water and by providing cover using cloth bags or sacks. The finished stone masonry should be cured for a minimum of 7 days, or as instructed by the contract supervisor.

Work methods for construction of wing walls

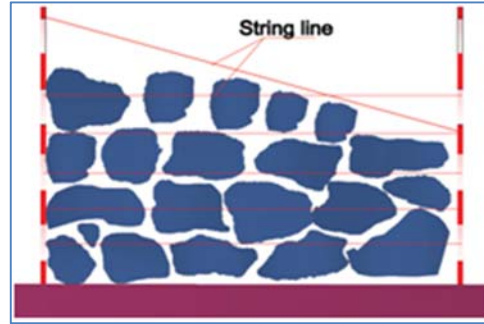
Wing walls are constructed at the inlet and outlet of culverts to prevent soil erosion which occurs as water enters or exits the culvert.

✚ **Setting out** for wing walls should be at an angle of 30° to 60° to the culvert centre line. On skewed culverts, the angles of the wing walls at each side is not necessarily the same. In such cases, the angle depends on the angle between the road centre line and centre line of the culverts. It should be remembered that head walls of the culvert should be parallel to the centerline of the road. Setting out for the wing walls should include:



- ✓ Setting out the desired angle between the center line of the culvert and the wing wall and place pegs at all the corners,

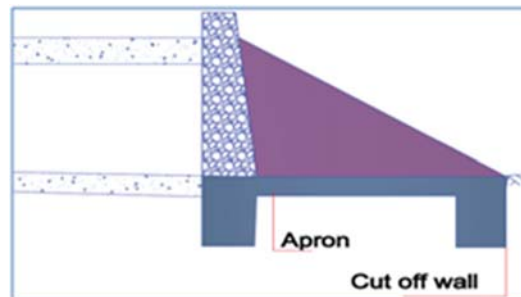
- ✓ Setting out the correct length of the wing walls at the corner of the pegs.
- ✓ Mark the height of the wing walls on the pegs (at the headwall side and outer ends),
- ✓ Setting out the thickness of the wing walls,
- ✓ Use string line to guide the stone masonry works. Two strings should be tied in two parallel lines with a spacing of between 10 to 15 cm. Both string lines will be moved upwards following the progress of laying stone for the masonry work

**Stone masonry work.**

- ✓ Mix and place lean concrete of 5 cm at the bed of the wing wall. Mixing proportion for the lean concrete should be 1:3:6,
- ✓ Construction technique for the stone masonry work are described in Module K for the construction of stone masonry chapter.
- ✓ Allow for weep hole for every 0.5-0.7 m along the stone masonry wall. The diameter of the weep holes should be 5 - 7 cm.
- ✓ The finished stone masonry work shall be cured immediately after the mortar has started to harden by application of water and by providing cover using cloth bags or sacks. The total period of curing shall a minimum of 7 days, or as instructed by the contract supervisor.
- ✓ The stone masonry works for the wing walls and the abutment walls should be constructed at the same time.

Work Methods for construction of aprons and cut off walls

Aprons and cut off walls are constructed to avoid scouring of the soil close to the culvert inlet and outlet. The depth of the cut off walls is normally the same depth of the of the abutment foundation. The aprons and cut off walls can be constructed by concrete or stone masonry. This module describes construction of the apron and cut off walls using stone masonry.

**Setting out**

- ✓ Set out the thickness of the aprons.
- ✓ Set out gradient of aprons using a line level. The aprons should be set out with the same gradient as the culvert bed.
- ✓ Set out the depth and thickness of the cut off walls. The top level of the cut off walls should be the top level of the apron walls.

- ✓ Use pegs and sting line to control the level and thickness of the aprons and cut off walls

 Stone masonry work for the aprons and cut off walls.

The construction method for stone masonry work for the aprons and cut off walls are described in Module K for the construction of stone masonry chapter. The aprons and cut off walls can be constructed after or at the same time as the construction of the wing walls.

Step 4 Construction of the culvert slab

The culvert slab should have enough strength to carry the expected traffic load. The culvert slab is therefore usually constructed using reinforced concrete. This Module describes the construction of culvert slab using reinforced concrete.

Material for the concrete slab

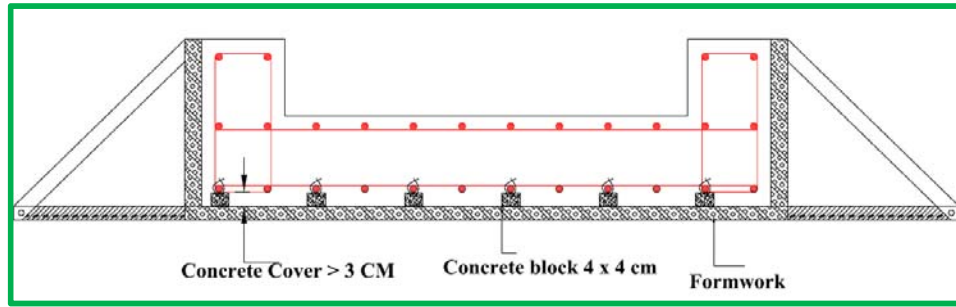
The culvert slab is constructed using reinforced concrete. The materials required for the reinforced concrete are: crushed aggregate, sand, cement, water and steel bars. The required characteristic of the material are described in Module for the construction of concrete chapter.

Work Method

 Formworks and supports

Formwork and formwork support is required for forming the concrete slab of the culvert.. Material for the formwork should be timber planks with thickness of not less than 20 mm and timber 50x70mm timber beams for the support. Plywood can be used instead of timber planks, however in this case the timer beams should be placed closer as the plywood usually is weaker than timber planks. The formwork is placed on supporting poles.. The preparation of the formwork should follow the steps below:

- ✓ Place the supporting poles on firm ground, or where the ground is not fir enough on a firm element like a rock or piece of timber/wood. The space between the supporting poles should be between 40-50 cm.
- ✓ Timber support beams should be nailed onto the supporting poles.
- ✓ Place and fix the timber planks on the timber beams. The timber planks should be placed as close as possible to each other to minimize gaps between the planks. The planks must be fixed by nails
- ✓ Complete the sides of the box for the formwork and fix by nails. The height of the formwork sides should not be less than thickness of slab and wheel guard

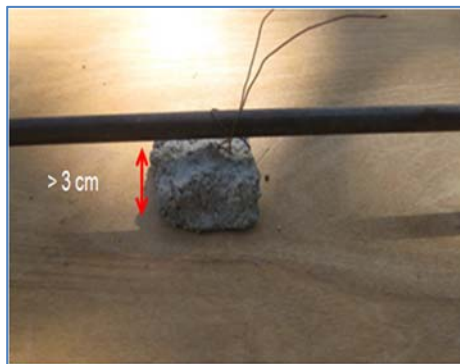


Fix and place steel bars

Steel bars for the culvert slab can either be high tensile or mild steel depending on the design. The steel bars normally rusts slightly when in storage so they should be cleaned before use with a wire brush.

It is also necessary to make spacer blocks in advance, normally from cement sand mortar with a steel wire embedded in the block to make it easy to tie the block to the steel bar.

These blocks will be tightened to the steel bars so that they do not move when the concrete is being poured.



- ✓ The steel bars should be cut and bent to match each bar as shown on the drawings. Each bend should be made around of 5 times the diameter of the steel bar.
- ✓ These steel bars should be fixed together to match the bars as shown on the concrete drawings. Spacer blocks should be fixed to the steel bars of spacing about 30-40 cm. bend or move closer to the formwork when concrete is being poured or when workers walk on the mesh. Note that concrete cover must at least be 30mm.
- ✓ If a single length of reinforcement steel is not long enough to form an entire bar as shown on the contract drawings, two lengths can be used with an overlap of 30cm (or 40 times to the diameter of the steel for rounded steel

bar and 28 times to the diameter of the steel for deformed bar). The overlap must be fixed with at least three separate loops of fixing wire.

✚ Mix, place and compact concrete for the culvert slab.

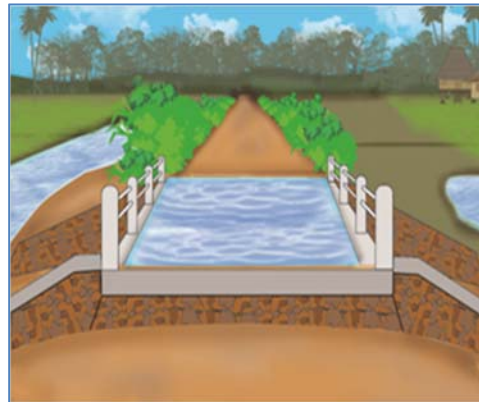
Concrete for the culvert slab should be mixed using a concrete mixer. The concrete mixing proportion should follow the drawing or specification. In general the mixing proportion for the concrete slab should be 1:2:4. Slump cone test should be carried out during the concrete mixing. The slump for the concrete slab should be between 50-125mm. Water-cement ratio should be 0.4-0.5 so the quantity of water to be used should be 16-20 liters for 1 bag of cement (40 kgs). Note do not add more water as that will result in a weaker concrete.



✚ Compaction of the concrete

The concrete for the culvert slab should be mechanically compacted in order to achieve high quality and strength, preferably using a poker vibrator. However, this equipment may not be available, and for smaller box culvert slabs, hand compaction can be accepted upon approval of the client's engineer.

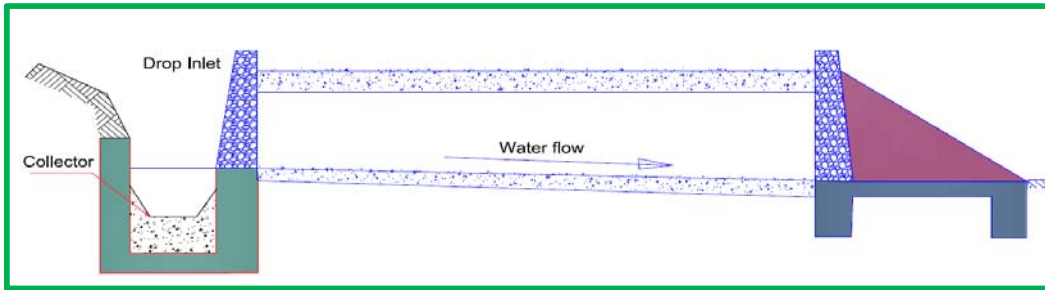
The process for mixing, hauling, placing and compaction of the concrete for culvert slab is described in Module K for the construction of concrete works chapter.



✚ Curing concrete

The concrete must be cured with water to prevent the concrete drying out during the setting and hardening stage. The curing must commence after 3-4 hours after pouring the concrete. It is necessary to keep the concrete surfaces continuously wet for at least 14 days. The best option for curing concrete for the culvert slab is by sprinkling water on the concrete surface, keeping a permanent wet surface, or by making a pond of water on the concrete. Other curing options can be found in the Module K for the construction of concrete chapter.

Step 5 Construction of drop inlets to culverts



The drop inlets are constructed to assist in overcoming erosion on inlet side of culvert and excessive silting in sandy or non-plastic soil condition.

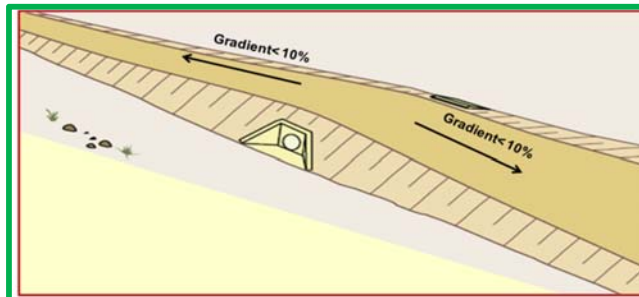
The drop inlet is commonly constructed for culvert built in mountainous or rolling terrain, the road is often constructed as a side cut in sloping terrain. The function of the drop inlet for this culvert is to collect water from the side drains and feed it through the culvert and discharge the water on the lower side below the road.



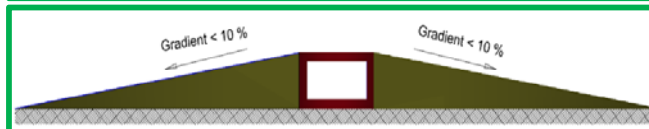
Drop inlets are usually made of the same materials as the wing walls, such as concrete or stone masonry. The thickness of the walls of the drop inlet should follow the thickness of the wing walls. The level of the inlet of the collectors should be at the same level as the side drains, and its size and shape should follow the size and shape of the side drains.

Backfilling and fill approach for the culverts

The material used for backfilling shall consist of selected material like gravel for surfacing quality. Back fill the wing walls and abutment walls should be compacted using a tamper.



Back fill for approach road of the culvert shall be placed at optimum moisture content and compacted with roller in layers, not exceeding 150 mm.



The approach road should be built with a longitudinal gradient not greater than 10% otherwise length of the approach should be extended

Work Method

- 🔧 Remove any protective supports, bracing or shoring as the backfilling progresses
- 🔧 Back fill should be carried out in layer. When one layer has been fully compacted, fill, spread, water and compact another layer

- ✚ The backfill for abutment walls and wing walls with weep holes shall be done with a vertical layer of granular fill materials of about 30-40 cm to serve as a filter. The granular material should be filled on top of the weep holes upward.
- ✚ Back filling for the foundation shall be done in layers not thicker than 100 mm, watered and compacted using a tamper.
- ✚ The backfill for the approach road should be done in layers not thicker than 150mm. Compaction of the soil should be carried out by roller until required density or until "refusal". Ensure that the gradient of the approach is less than 10%.

L-1-7 Quality control for Construction of box culvert

Quality control for the culvert construction involves the checking of the suitability, function, workmanship and strength of the cured stone masonry and concrete works. The test can be carried out by the Site Engineer/Supervisor to ensure on site that the quality meets the required specifications. The quality control shall be carried out in daily basis by contractor's field staff and the Client assigned field staff.

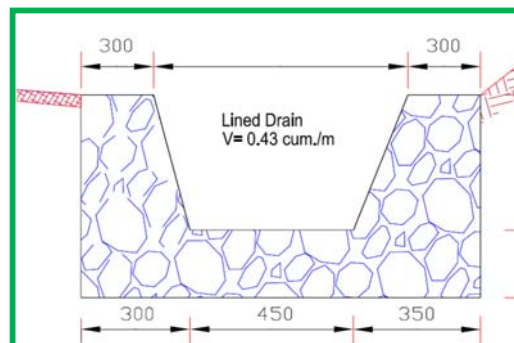
<i>Test Item/work activities</i>	<i>Test/check method</i>	<i>When</i>	<i>Tools</i>
Material: refer to material mentioned in stone masonry and concrete works			
Construction operation for culvert			
Identification for culvert location and position	✓ visual ✓ location: at lowest point of the side drain for relief culvert and at middle of the stream/channel for stream culvert ✓ position: perpendicular to the road for relief culvert and align to the direction of the stream or channel for stream culvert	Before commencing the construction	NA
Excavation for foundation:	✓ dimension check ✓ ensure pegs and string line are used for excavation of trench. ✓ dimension check, width and depth of the trench ✓ bed level must be placed on firm soil and at the designed depth. ✓ excavated material, if suitable, can be kept for back filling. Bad material must be throw away from road formation making sure not to block the drainage system	During carrying out the activity	Measuring tape
Concrete bedding	✓ Visual check ✓ ensure bedding is levelled and at the designed level. ✓ mixing concrete: Perform the test refer to quality control for concrete work ✓ dimension check thickness of the concrete	During implementation of the activities	Measuring tape

Setting out for stone masonry abutment walls and wing walls		✓ visual check: ensure pegs and string line are used. ✓ dimension check, width and height	Before commencing masonry work	Measuring tape
Laying stone and weep holes		✓ Perform test/check as mentioned in quality control for stone masonry work	During carrying out the masonry work	Measuring tape
Aprons and cut off wall		✓ Visual check ✓ ensure excavation reach to designed depth. The bed surface is levelled ✓ dimension thickness of the apron and depth of the cut off wall ✓ Top surface of the concrete / masonry is levelled	During carrying out the activity and after completion	Measuring tape
Back filling		✓ Visual check ✓ back fill material according to the design. ✓ back fill to level of top of the abutment wall and wing wall ✓ compaction to the required degree	After completion of the work	Measuring tape
Curing the wing and the abutment walls		✓ keep wet: to cover by bag or sand and continue adding water	always for min. 7 days	NA
Reinforced Concrete slab	form work and support	✓ dimension check for formwork. ✓ visual check, gaps of the formwork must be minimal ✓ visual check support: size and strength, spacing from one to other, bracing connecting all support, ✓ visual check the support: must be placed on a hard surface	Before commencing placing steel bars	Measuring tape
	steel fixing	✓ Check that the correct amount and type of steel has been delivered to site. ✓ dimension check diameter of the steel ✓ visual check: type of the steel ✓ spacing. ✓ over lapping joints ✓ concrete block for clear cover	Check placing of steel before commencing concrete work	Measuring tape,
	concrete	✓ Perform test/check as mentioned in quality control for concrete work	During concrete mixing and pouring	Measuring tape, slump cone and mould
	curing	✓ keep wet: to cover by bag or sand and continue adding water	always for min. 15 days	NA
Approach road		✓ visual check of filled material ✓ ensuring compaction layer < 15 cm ✓ ensure longitudinal gradient < 10% ✓ perform compaction test after compaction	During construction and after completion	Measuring tape, DCP

Final check for finishing work	✓ Visual check ✓ all remaining material has been cleared from site ✓ formwork is removed after min. 14 days and taken away from site ✓ inlet and outlet are free from blockage material	After completion of the work	NA
--------------------------------	--	------------------------------	----

L-2 Stone masonry lined side drains

L-2-1 Introduction



Side drains are constructed to collect water from road carriageway and surrounding areas and lead it to an exit point where it can be safely discharged. Drains need to have sufficient capacity to collect all rainwater from the road carriageway and discharge it quickly to avoid further erosion.

To minimize erosion and high maintenance costs, especially for side drains built in mountainous terrain or on roads with steep gradients > 10 % the side drains should be lined by rocks, brick, stone masonry or concrete depending on the availability of construction material in vicinity of the road. This chapter describes the construction of side drain lining with stones masonry.

L-2-2 Construction material

The side drain lining with stone masonry are constructed from cement stone masonry. Material required for the stone masonry are: stone, cement, sand and water. The required characteristic of the material for the stone masonry works are described in **Module K for the construction of stone masonry chapter**.

L-2-3 Tools and equipment:

The following plant, tools and equipment are recommended for the construction of stone masonry lined side drains:

Steel or wooden pegs	Measuring tape – 3 m or 5 m
Hammer	Steel and/or timber shutters/formwork
Line level	Concrete mixer for mixing concrete and mortar (hand mixing is acceptable for mortar mixing)
Ranging rods and profile board	200 litres drums for storing water
Pick axes and shovel	Screed
Wheelbarrows	Trowels
Hand tamper or hand rammer	
Buckets	

L-2-4 Work Method

Step 1:

- ✚ Set out the trench for construction of the side drain with dimension as shown in the drawing.
- ✚ Excavate the trench in rectangular shape until the drain foundation.
- ✚ Set out and place wooden frames for every 5 m along the road. The wooden frames are set out to follow the inner dimension of the lined side drain
- ✚ Set out the top level of the stone masonry lined side drain by transferring the level of the road shoulder by using line level. The top level of the lined drain is then marked on the wooden frames.
- ✚ Set out the thickness of the stone masonry walls (outer frame) by measuring from the inner wooden frame. The thickness should be in accordance to the drawing
- ✚ Mark the thickness of the stone masonry at the bottom of the drain using a string line.



Step 2

- ✚ Mixing cement mortar for the stone masonry work. The mixing proportion for the cement mortar should be 1:3 or 1:4 as shown in the drawing or technical specifications. To measure the correct mixing proportions, a measuring wooden box should be used. Water cement ratio should be 0.4-0.5= 16-20 liters of water for 40 kg of cement



Start placing the stone masonry work.

The bottom of the lined drain should be constructed first. Once the stone masonry for the bottom is completed, the stone masonry walls can commence.

Step 3

- ✚ Fix string line for stone masonry walls. Two strings should be tied in two parallel lines with a spacing of between 10 to 15 cm. The string line will be moved upwards following progress of laying stone for the stone masonry work.
- ✚ Place selected large stone for the bottom layer. Stones shall be laid with their longest face horizontal.
- ✚ Cement mortar shall be placed before and after placing each piece of stone and fill all the gaps. The thickness of cement mortar shall be in the range of 2 to 5 cm.
- ✚ In big gaps between stones, small hard stones should be fitted and filled along with cement mortar. Then pointing the joints should be made for finishing work.



Step 4 Curing: The finished stone masonry work shall be cured immediately after the mortar has started to harden by application of water and providing cover using cloth bags or sacks. The period of curing shall be Minimum 7 days.

Note:

The construction of stone masonry drains require skilled masons. Laying stone for the



stone masonry work should be done in layer.

Step 5 Back filling

The material used for backfilling shall consist of selected material of at least the same quality as selected material used for gravel surfacing or sub-base. The back fill should be compacted by tamper.

L-2-5 Quality control for construction of stone masonry lined drain

Quality control for stone masonry lined drain involves the checking of the dimensions, workmanship, strength of the material and strength of the cured stone masonry work. The tests and checking can be carried out by the Site engineer/Supervisor to ensure on site that the quality meets the required specifications. The quality control shall be carried out in daily basis by contractor's field staff and the Client assigned field staff.

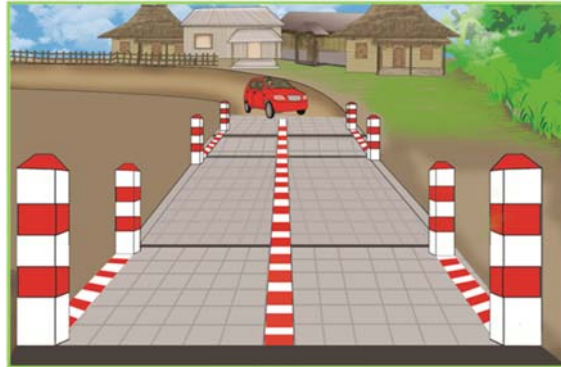
Test Item/work activities	Test/check method	When	Tools
Material: Refer to material for stone masonry work			
Construction operation for stone masonry lined drain			
Excavation of side drain and foundation for the stone masonry:	✓ ensure pegs and string lines are used for every mix (5 m interval) ✓ dimension check, width and depth of the ditch ✓ bedding level must be placed on firm soil and at the designed level ✓ good material from the excavation that can be used for road work can - IF INSTRUCTED - be thrown onto the road Bad material to MUST be thrown away from the road.	When carrying out the excavation	Measuring tape
Mixing mortar	Perform the test refer to quality control of Mortar		
Setting out	✓ Visual check : ✓ ensure pegs and string lines (double string with 10cm space) are used for every mix. 5m interval. ✓ dimension check, width and height	Before commencing masonry work	Measuring tape
Laying stone, starting with the bottom of the drain before constructing the walls. back fill and curing	✓ Perform quality control as mentioned in Quality control for stone masonry work and culvert construction	When carrying out the masonry work	Measuring tape
Final check for finishing work	✓ Visual check ✓ all remaining material is cleared from site ✓ excavated material spoiled away from road formation	After completion of the work	N/A

	✓ the lined drain is cleared and free from blockage material		
--	--	--	--

L-3 Drift

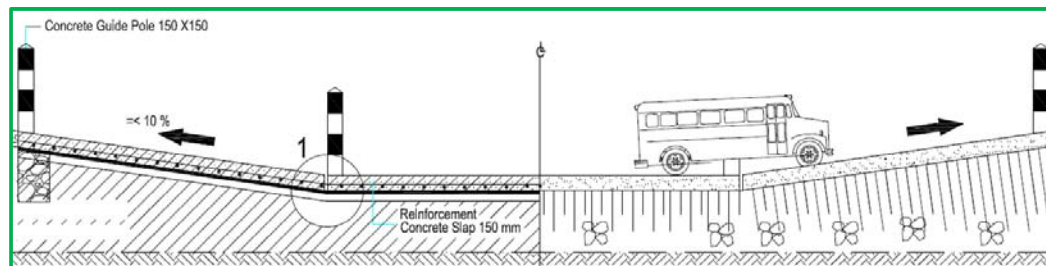
L-3-1 General Introduction

Drift is a drainage system on a road that allows water to flow freely across the road surface in such a way as to prevent damage to the road. Drifts may be used as the primary means of taking flash water across a road, but are some time used together with a culvert to carry the frequent water flows (called causeway). The drift should only be designed for perennial streams and only where the maximum water level above the drift is less than 40cm



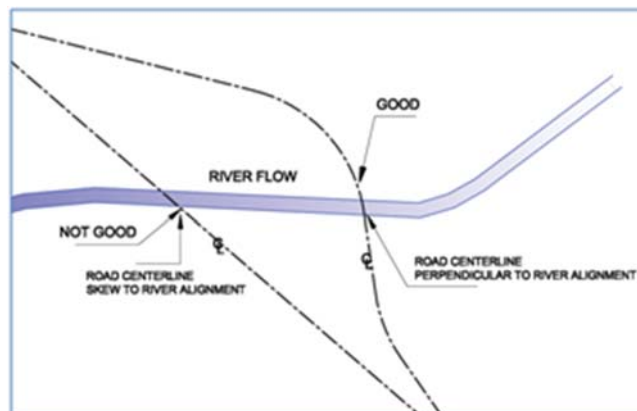
The most important part of a drift is that flash water is controlled and prevented from eroding the road surface and road slope. This may be done with a stone masonry wall or with a gabions. The road surface itself may be protected with a layer of stone or concrete.

Drift is also constructed to pass river streams which are dry during long periods of the year. If the waterway has a continuous flow of water throughout the year cause ways or culverts or bridges should be considered.



L-3-2 Selection location for a drift

It is important to select the right crossing point for the drift. If the location of the river crossing is wrongly selected it will result in increasing the amount of works and increasing construction and maintenance costs. Some main points to be considered for selecting location to construct a drift such as:



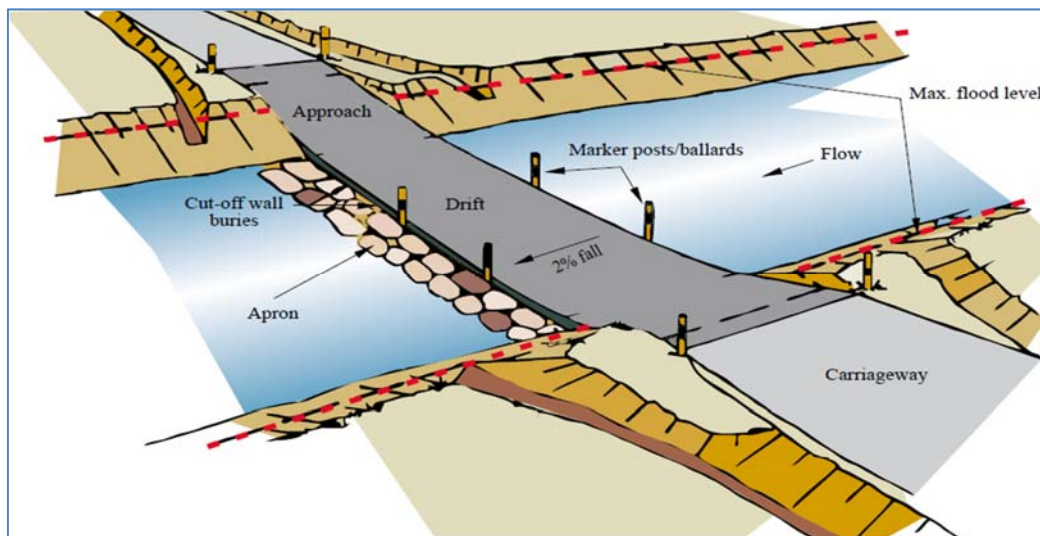
- ✚ The centre line of the road should be perpendicular to the flow of the water.
- ✚ Center of the drift bed should follow the water flow direction.
- ✚ Avoid places where there are signs of scouring or silting that will cause future maintenance problems.
- ✚ Avoid places where there are steep banks which will involve a lot of excavation and steep approach slopes.
- ✚ Drifts are not suitable where water is fast flowing or the volume of water would endanger the passage of vehicles, people or animals.

After selecting the location for the drift it is also important to establish level for bed of the drift. The bed level of the drift should be set in the same level as the river / stream bed. If the bed level of the drift is lower than the riverbed level the drift will be silted, but if the bed level of the drift is higher than level of the river bed scouring at the inlet and outlet will occur.

In cases where the river is suffering from silting up, it is best to lift the drift 20 - 25 cm above the natural river bed. This will speed up the water passing over the drift and reduce the danger of the drift becoming silted up.

L-3-3 Main features of a drift

Similar to other road crossing drainage structure, a drift consists of several main elements. Each element has its own function and use difference type of material for the construction. Figure below shows main elements of a drift.

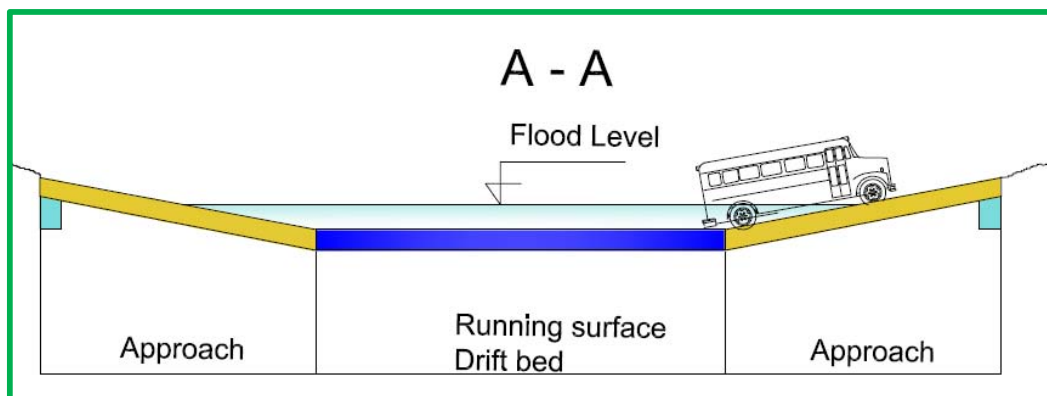


- ✓ Drift approach
- ✓ Running surface and approach surface
- ✓ Cut off walls
- ✓ Apron
- ✓ Marker posts or guide posts

L-3-4 Design considerations for the drifts

✚ Drift approaches

The slope for a drift approach should ideally not be greater than 10%. The approaches should allow vehicles comfortably to and leave the drift. However steeper gradients may be necessary if the banks are higher. For short length of the drift (less than 10 m), the approaches should not be steeper than 5%. The approaches should be surfaced using the same material for the running surface of the drift. The approaches length and surface must be extended beyond the flood level.



✚ Drift Surface

The surface of a drift will support traffic flow as well as stand up to the water flows in the rainy season. The surface should be constructed with a gentle slope of about 2% toward the downstream to ease the water flow. There are a number of possible types of surfaces, including gabions, stone pitching, stone masonry or concrete slab. The choice depends on the following issues:

- ✚ the expected force of the water flow,
- ✚ the availability of materials, such as stones, aggregate, sand, etc.,
- ✚ the strength of the river bed foundation, and
- ✚ costs of labour and materials.

For slower flowing water, stone pitching should be adequate. At some crossings, stone pitching is not practical as it may be washed out too often. In these cases, the surface could be protected using gabions and allow a full rainy season before deciding whether it is necessary to upgrade the crossing to a stronger surface.

Where large volumes of strong of flowing water are expected, a concrete slab or cement stone masonry with a solid base should be considered as a long-lasting solution.

Cut-off walls

The cut off walls are constructed to prevent scouring at downstream and upstream of the drift. An upstream cut-off wall reduces the seepage and lifting forces of water passing under the structure and cut-off wall at downstream which anchors the drift bed and prevents scour undermining the structure.

The cut off walls are constructed using a wide range of options, including stone masonry, concrete or gabion.

Aprons

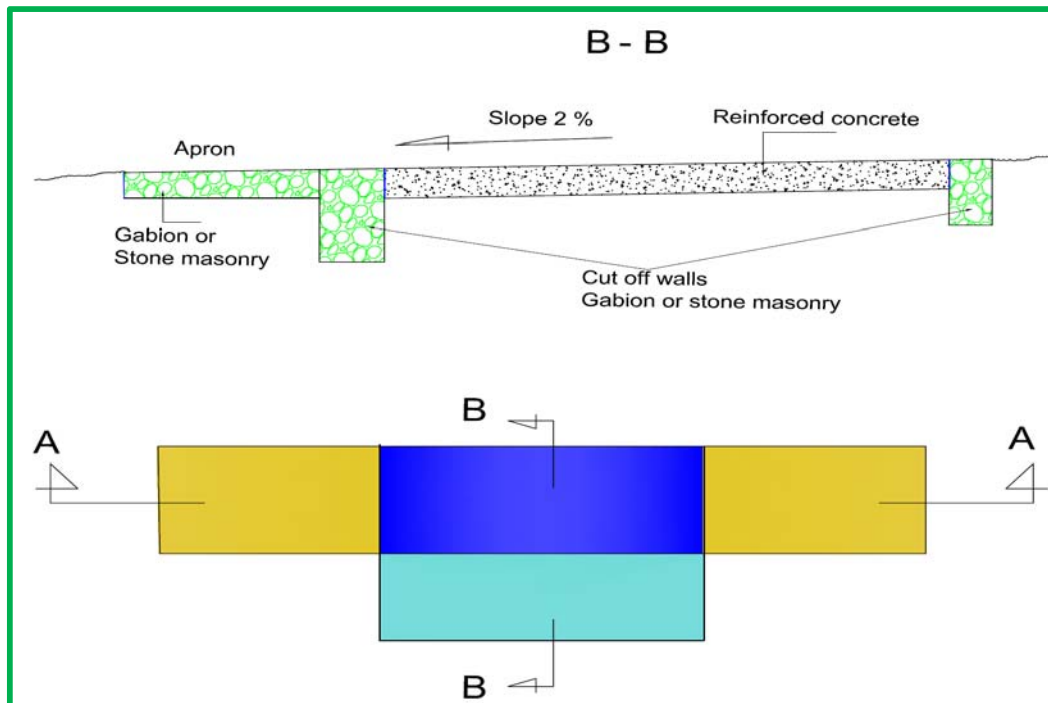
An apron is required immediately at downstream to protect the structure from erosion by the turbulence that will be created by the structure. The Aprons are constructed by wide range of options including stone masonry, stone pitching, gabions or concrete. The best options is to construct the aprons using same type of material as material for cut off walls.

A good alternative to stone masonry, for constructing aprons and cut off walls, that requires good quality stones and skilled masons is the use of gabions.. Gabions have the advantage that: (i) they are easier and faster to build, (ii) stone of lesser quality and size can be utilized, which are easier to find locally, (iii) gabions are more resistant to erosion and (iv) they do not require skilled masons.

L-3-5 Construction

Drifts for rural roads in Timor Leste are sometimes designed to use reinforced concrete for surface and gabion or stone masonry are used for cut off walls and apron.

A typical cross section of a drift (concrete slab, stone masonry or gabion for cut off walls and apron) is commonly use as shown below.



Material for the construction of a drift

- ✚ **Reinforced concrete:** Required material for the construction of concrete surface are: crushed aggregate, cement, sand, water and steel bars. The required characteristic of these material are described in Module K for the construction of concrete chapter.
- ✚ **Stone masonry and Gabion:** Required material for stone masonry or gabion for cut off walls and aprons are: large stone, sand, gabion basket, cement, water. The required characteristic of these material are described in Module K for the construction of stone masonry and gabion chapters.

Construction plant, equipment and tools

The following plant, tools and equipment are recommended for the construction of drifts by labour-based methods are:

Steel or wooden pegs	Timber shutters/formwork
Hammer	Concrete mixer for mixing concrete and mortar (hand mixing is also acceptable)
Pickaxe and shovel	Timber box for batching of aggregate, sand and cement (see Module 2)
Wheelbarrows	200 litre drums for storing water
Hand tampers	Screed
Pump and or buckets for dewatering	Wooden float
Line level	Trowels
Measuring tape – 3 m or 5 m	

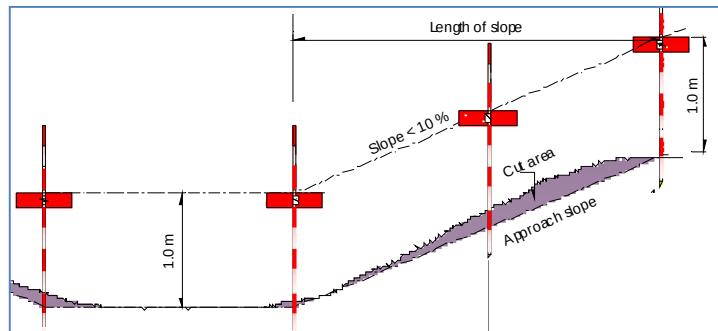
Work Method

Step 1 Construction of detour road

Prior to starting excavation of foundation for a drift a detour road should be constructed to divert the flow of traffic from the working place during the construction work. It is important to keep traffic open at all time during the construction of the drift. The construction process of the detour road is described in this Module chapter L-1

Step 2 Setting out

- ✚ Set out centerline of the drift: the draft centerline should be 90° to the alignment of the riverbed.
- ✚ Once the center line of the drift is set, determine length of the drift bed by measuring from center line of the drift.



- ✚ Set out approach of the drift. Two profiles boards are set out to a maximum 10% slope one at beginning and one at end of the approach. Raise the two profile boards 1m high. The third profile board moved between the two profile boards along the line of the slope. The third profile board is used to determine approach level to be cut or filled and this can be used to estimate the volume of excavation required. Repeat same process for other side of approach
- ✚ Set out final levels for the bed slab as shown in drawings.
- ✚ Set out shape and dimension of the drift as shown in the drawing.
- ✚ Set out trench for foundation and cut off walls in rectangular shape. Dimension of the foundation are shown in the drawing.

Step 3 Construction of foundation and cut off wall

- ✚ Cut, shape and level the high part of the approach. Material from the cut dispose outside the drift site.
- ✚ Excavate trench for the foundation and cut off walls of the drift. Width and depth of the foundation and cut off walls of the drift refer to drawing.
- ✚ Construction the cut off walls and foundation. There are two techniques for constructing the cut-off walls and apron these are:
 - ✓ use stone masonry: The construction technique is described in Module K For construction of stone masonry chapter.

- ✓ use gabions: The construction technique is described in Module K For the construction of gabion chapter.

Step 4 Construction reinforced concrete for running surface and approach surface.

The reinforced concrete for running surface and approaches surface layers will be constructed as per the engineer's design. Dimension, thickness and mixing proportion in accordance in the drawing. Steps of the construction to follow:

- ✚ Set out surfaces level (running surface and approach surface) and fix formwork for concreting the surfaces.
- ✚ Prepare and level bedding. Ensure the bedding are well compacted and material for the bedding in accordance to the drawing.
- ✚ Fix steel bars as shown on the drawings. Mortar blocks spacer to be fix at the steel bars for spacing of 30-40 cm each mortar block.
- ✚ Batch, mix, place, compact and cure the concrete as technique described in Module K construction of concrete chapter.
- ✚ If the concrete for running surface and approaches are longer than 5 m, expansion joints are required. Technique for constructing the expansion joints are described in Module K for construction of concrete chapter.

Remember: Prior to placing concrete to form for the running surface and approach surface the following steps must be taken:

- ✚ Are all formworks set at the required spacing and levels and are they secured?
- ✚ Has the bedding base been properly constructed and compacted to the correct levels?
- ✚ Are all required material delivered on site.
- ✚ Has the layer been dampened prior to concreting?
- ✚ Are all necessary tools, plant and equipment at hand?

Step 5 Construction of apron.

- ✚ Set out width, length and top level of apron in accordance to the drawing.
- ✚ Excavate and prepare for apron bed level. Ensure the bedding are well compacted and material for the bedding in accordance to the drawing.
- ✚ Construct the apron. There are two techniques for constructing the apron as shown in step 3 of chapter K-3-6-3

Step 6 Drift Warning

It is important to place sign posting to warn traffic of the location of a drift or river crossing. The sign posting should be placed on the side of the road at both ends (before 30m and after 30m) of the draft. Traffic can then reduce speed and proceed safely down the



approach and across the drift. Or otherwise some guidance can be given in the form of marker stones painted white and placed along both ends of the drift.

L-3-6 Quality control for drift Construction

Quality control for drift construction involves the checking of the dimensions, strength of material and workmanship. The tests and checking can be carried out by the Site Engineer/Supervisor to ensure on site that the quality meets the required specifications. The quality control shall be carried out in daily basis by contractor's field staff and the Client assigned field staff.

Test Item/work activities		Test/check method	When	Tools
Material for stone masonry and concrete works				
Stone, sand, cement, water, aggregate, gabion basket and geotextile		✓ Perform quality control as mentioned in quality for concrete and stone masonry and gabion works		
Construction operation for drift construction				
Identify location and position for the drift		✓ visual ✓ location: at the middle of a stream /channel ✓ position: alignment of the drift must perpendicular to the river flow.	Before commencing the construction	Measuring tape and line level
Excavation for foundation and approach:		✓ dimension check ✓ check pegs and string line are used for excavation of the foundation and approaches. ✓ dimension check width and depth of the foundation ✓ excavated material keep aside for other use and bad material throw away from road formation and not blockage the drainage system	During and after carrying out the excavation activity	Measuring tap, line level and profile boards.
Setting out for stone masonry cut off wall, apron and foundation.		✓ visual check: ensure pegs and string line are used. ✓ dimension check width and depth of the foundation are marked on the pegs ✓ Top level of the cut off wall, apron and foundation	Before commencing masonry work	Measuring tape
Stone masonry work for cut off wall, foundation and apron		Perform quality control as mentioned for quality control for stone masonry work. If the cut off wall and foundation are designed to use gabion perform quality control as mentioned in the quality control for gabion work		
Concrete slab for running surface and approach	form work or edge supports	✓ dimension check for formwork or edge support. High and level of the formwork ✓ Check if the enough support for the formwork	Before commencing placing concrete.	Measuring tape

	concrete	✓ Perform test/check as mentioned in quality control for concrete work	During carrying out concrete mixing and pouring	Measuring tap, slump cone and mould
	curing	keep wet: to cover by bag or sand and continue adding water	always for min. 14 days	NA
Final check for finishing work		Visual check: ✓ all remained material are cleared from site ✓ formwork are removed ✓ Clear water ways inlet and outlet	After completion of the work	NA

L-4 Gabion works

Introduction

Gabions are wire mesh boxes filled with stones and tied together to form basic structures. They are used principally for retaining walls, drifts and erosion protection.

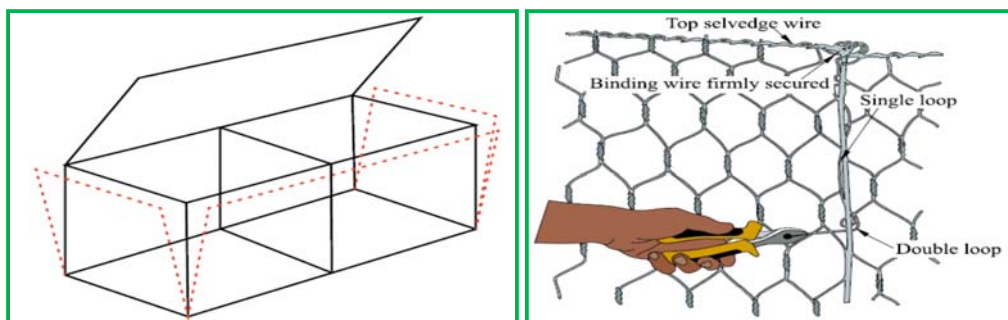
Gabion boxes may be made by purpose made gabion cages, welded steel mesh sheets and galvanized chain link fencing. The steel wire or mesh is galvanised to protect the steel from rusting. Galvanised wire is also used for tying the boxes together, for internal bracing and for closing the lids.

Gabion boxes come in many sizes. Common gabion box sizes in Timor-Leste are 2 x 1 x 1 m and 2 x 1 x 0.5 m. The use of gabions boxes is particularly suited for labour based road works implementation as the construction of gabion structures is carried out manually and as the stones to fill the boxes are found locally. Gabion boxes are commonly used in Timor-Leste for protection of slopes prone to erosion.

L-4-1 Construction of gabion structures

Step 1: Foundations should be excavated until firm soil and level. Any unsuitable material should be removed and replaced with good soil, stone or gravel and then compacted.

Step 2: Gabion cages should be woven together using 3 mm binding wire, securing all edges every 150 mm with a double loop. The binding wire should be drawn tight with a pair of heavy duty pliers and secured with multiple twists. The connected baskets should be stretched and staked with wires and pegs to achieve the required shape.



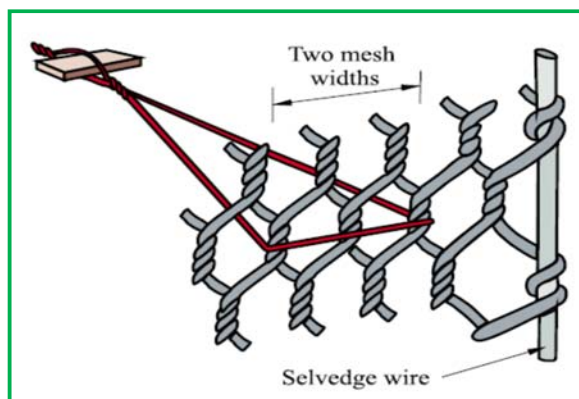
Step 3: Fill baskets by hand using hard durable stones (avoid using weathered stone) not larger than 250 mm and not smaller than the size of the mesh. The stones should be tightly packed with a minimum of voids, placed as if for dry stone masonry. The best size range is 125-200 mm. The range of suitable size of the stone depends on the height the gabion box.

Table below shows recommended stone sizes.

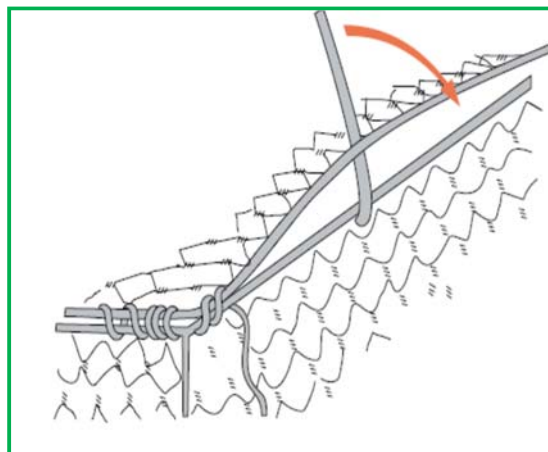
Height of unit mm	Stone size mm
170 to 230 mm	Min 100 to max 125 mm
230 to 300 mm	Min 100 to max 200 mm
Over 300 mm	Min 100 to max 250 mm

A gabion box which is 1 m high should be filled to 1/3 of its height then fitted with horizontal bracing wires, tensioned with a windlass, to keep the vertical faces even and free of bulges. Further bracing should be fixed after filling to 2/3 height of the box. A gabion box of 500 mm height should be braced at mid-height only while a gabion box of 250/330 mm height does not require internal bracing.

Where water fall directly onto the top of the gabion, vertical bracing wire should also be fitted to secure the gabion lid when closed. The stones should be carefully packed to about 30–50 mm above the top of the box walls to allow for settlement. Smaller material can be used to fill the voids on the top face, but excessive use of small stones should be avoided.



Step 4: Fit the lid to the basket. Use the closing tool (crowbars) to stretch the lid tightly towards the side of the basket and lace it into place. Lace the edges with wire with a single loop followed by a double loop, at about 100 mm intervals. Lace the mattress lids to the diaphragms as well. Inspect the basket carefully, making sure that every edge is securely laced, every diaphragm is fastened to the sides and the lid and that the basket is tightly filled with stone. Continue in this



fashion until the job is complete.

Step 5: Backfill the space between the gabion and the earth face with soil, gravel or broken stone and provide proper compaction. The back filling should be done immediate after completion of the gabion work before commencing next layer of the gabion. The material for the back filling must be the selected material to avoid using unsuitable material.



L-4-2 Quality Control For Gabion works

Quality control for the gabion work involves the checking of the suitability strength of material and workmanship. The tests and checking can be carried out by the Site Engineer/Supervisor to ensure on site that the quality meets the required specifications. The quality control shall be carried out in daily basis by contractor's field staff and the Client assigned field staff.

Test Item/work activities	Test/check method	When	Tools
Material for gabion work			
Stone	✓ Hardness or strength, durability of the stone as mentioned in quality control for stone masonry work ✓ size: most stone should be 15 to 30 cm + some small stone of size 5 cm. width > 1/3 of height	Before supply/ procurement	N/A
Wire baskets	✓ dimension check the galvanized wire to product the gabion box or mattress ✓ visual check size of the gabion basket or mattress	Before supply/ procurement	Measuring tape
Geotextile	✓ visual check to compare to specification		
Construction operation for gabion			
Excavation and preparation for foundation:	✓ dimension check ✓ ensure pegs and string line are used. ✓ dimension check, width and depth of the trench ✓ bedding level must reach to firm soil or rock. Bed is levelled and sloped 6% ✓ excavated material, if suitable, can be kept aside for back filling. Bad material must throw way from road formation or as instructed by client engineer.	When carrying out the excavation	Measuring tape and line level

Setting out for gabion work	✓ visual check: pegs and string line are used to ensure the gabions are placed and aligned correctly, and at the right location	Before placing the gabion baskets	Measuring tape
Assemble and place the gabion basket	✓ visual check ✓ the gabion baskets are fixed and properly tightened using galvanized tying wire for all edges at every 150 mm with a double loop. ✓ geotextile is placed on the smooth surface of the foundation. ✓ Set out using pegs and string line to ensure the gabions will be placed and aligned correctly ✓ the gabion baskets are placed on the geotextile with the lip of the box open. The empty gabion baskets are tied and fastened to adjacent baskets along the top and vertical edges.	Before placing stone	Measuring tape
Placing stone	✓ Visual check ✓ ensure stones place in the empty gabion basket as dense as possible and fill all gaps with smaller stone. ✓ if the gabion basket is higher than 30 cm horizontal bracing wires shall be used. ✓ the cover lips are tighten after the stones are filled	During installation of the gabions	Measuring tape
Back filling	✓ visual check: ✓ ensure geotextile is placed inside surface of the gabion. ✓ filling of selected material layer of each less than 15 cm and proper compact. Continue to top level of the gabion. ✓ ensure the back fill is done before commencing next layer of the gabion work ✓ ensure final level of the back fill is same level of road shoulder	During and after installation of gabions	Measuring tape
Final check for finishing work	✓ Visual check ✓ all remaining material has been cleared from site ✓ excavated material is spoiled away from road formation and as instructed by the client engineer	After completion of the work	N/A

L-5 Safety and health for drainage structures and erosion protection works

This includes the provision of general safety and health measures for labourers on site for the construction of drainage structures and erosion protection works such

as: construction of culverts, small bridges, drifts, masonry lined drains, gabions and stone masonry retaining walls.

L-5-1 Safety Measures

- + Carry out a safety briefing for all workers before works begin. Make sure work is organized so that each worker has enough space to carry out his or her task without endangering co workers.
- + Place warning signs or cones at each end of the work area. The warning signs should be placed 50-100 m away from the working areas. The text on the warning signs should read: "KUIDADU" or " HALAI NENEIK"
- + All equipment operators must be trained in the use of their equipment (trucks, rollers, mixers, etc). Equipment must be in good condition and safety covers for moving parts should be used.
- + Deep excavations (more than 1.5 m) for foundations etc shall be clearly marked and fenced off in a way that people cannot fall into the excavation. The sides of excavations must be made safe, either by ensuring a sufficient angle of the slope or by shoring up the side walls with planks, so that they do not fall onto workers in the excavation.
- + Reinforcement bars sticking out where concrete has not yet been poured must be clearly marked to avoid cutting or spearing accidents. The whole such area should be clearly marked and sealed off to make sure no one accidentally steps or falls into uncompleted structure works.
- + No children are allowed enter in the work area.
- + The contractor shall not allow the use of alcohol or drugs on the works site or in the site camp.

L-5-2 Drinking water:

Drinking water must be available within 50 metres of all work sites approximately 2 litres should be available per worker per day

L-5-3 Safety Gear:

The Contractor is responsible for safety on site and must explain clearly to all workers any potential danger of various work activities and what precautions to take to avoid any accidents on site. The Contractor shall provide appropriate safety gear in sufficient numbers. All workers must be instructed how and when to use safety gear and items shall replaced when unusable or lost: The Contractor shall provide safety gear as listed below.

- + Safety jackets in bright colours for supervisors and for all workers if working on a road that has frequent traffic
- + Closed shoes and gloves for all workers for general road works. Note that cotton gloves need to be replaced regularly
- + Gum boots and good quality gloves when working with sharp tools (e.g. pick axes), Carrying heavy loads, masonry work, working in muddy places

-  Hard hats for workers working in danger of falling objects, eg, in deep drains, in quarries, under a bridge, etc.
-  Dust masks when working with activities that produces lot of dust or bad smell.
Note that dust masks must be replaced regularly
-  Safety goggles must be used when breaking rock or crushing stone or anytime there is a risk for eye injury

L-5-4 First Aid:

A first aid box must be provided on site and must be regularly checked and restocked.

LBT Training Manual

Module M

Cross Cutting Issues

Table of Contents, Module M Cross Cutting Issues

M	Cross cutting issues [to be updated]	3
M-1	Gender and women's participation in LBT road works.....	3
M-1-1	Gender training	3
M-1-2	Gender sensitization	4
M-1-3	Recruitment of workers	4
M-1-4	Gender consideration during implementation.....	5
M-2	HIV/Aids awareness	7
M-3	Environmental issues	8
M-3-1	Mainstreaming environmental issues in LBT road works.....	8
M-3-2	Environmental mitigation measures during road construction	9
M-4	Occupational Safety and Health (OSH)	15
M-4-1	Safety and health office	15
M-4-2	Safety at work	15
M-4-3	Examples of Accidents	15
M-4-4	Causes of Accidents	16
M-4-5	Safety on Site	16
M-4-6	Health at work.....	18

M Cross cutting issues [to be updated]

M-1 Gender and women's participation in LBT road works

Whilst the overall objective of the rural road work is to facilitate economic development by improving transport accessibility so that community members can have better access to social services and economic opportunities (be they women, men, and children), the strategy of the government is to raise awareness of gender issues and involve women in both training activities and in road projects, at all levels, both as contractors, as workers and supervisors.

Men and women are often barred from certain jobs for various reasons - often due to a belief that women and men are fit for certain work only. If men or women are excluded from jobs they are able to do, actions should be taken to remove the barriers. This will help the individuals, the communities and the families.

A common perception is that there are no specific roles for women in road work activities, which have traditionally been carried out by men. The problem is compounded by the fact that there are indeed very few trained women as compared to men in this field. This has limited the number of women who would work in the roads sector.

Women and men both need access to gainful employment through participation in labour-based projects, which will help them contribute to their community and take care of their families. What has been largely ignored in the past is that when women earn an income, the money is spent mainly on the family, thereby leading to the improved welfare of the family, which is not necessarily the case when men earn an income. There is hence a need to encourage and promote women participation road works projects to maximise the impact of the wages spent in the community.

Rural works programs encompass a range of employment considerations and gender aspects must be considered throughout all activities.

M-1-1 Gender training

In order to address the gender imbalance and improve the women's opportunity to access jobs in the medium term, it is crucial to make sure that women have equal opportunity and access to training as the men do.

The government seeks to promote women participation, both as contractors and as workers on the road projects. The government has adopted a minimum target of 30% female headed contractors for the contractors training course, and encourages the Contractor to enroll women technical staff to participant in the training.

Orientation sessions on gender aspects should be carried out as part of the training of the contractors' personnel, and these issues should be continued during community consultations, which must cover gender aspects and labour practices for

the road works, and encourage women to participate in the road works as unskilled and skilled workers.

M-1-2 Gender sensitization

There is an immediate need to sensitize the stakeholders at all levels prior to the implementation of the road works to increase awareness on general gender issues and more so enlist women's participation in road rehabilitation process.

Sensitization shall be conducted at various levels and shall target different groups including local authorities, community leaders and community members and of course the contractors.

Women's decision to work is influenced by the economic needs and whether they could balance earning opportunities with domestic responsibilities. The Contractors shall provide information on how they are addressing gender issues in general and women's participation in particular.

Women are often intimidated to expressing their concerns and needs directly, in particular in a mix-sex consultation session. Organize therefore focus group discussions with women's groups to ensure their views and concerns are heard. Furthermore, women tend to be more comfortable to speak to a woman on women's issues and concerns.

Gender issues in road works and women's participation shall be part of sensitization and mobilization campaigns conducted at community levels where roads works shall take place. This may be done through

- ✚ community meetings;
- ✚ radio programmes;
- ✚ display of posters.

A specific Mobilization Site Meeting shall be held prior to commencing the road rehabilitation works by the Contractor who has been awarded the works. During this meeting which is facilitated by the Client, the Contractors and their staff including members of the community who are potential labourers shall be reminded of gender issues and women's participation in labour-based road works.

M-1-3 Recruitment of workers

The mobilization mechanisms are often not sensitive to the needs of women and therefore, in many cases, there is low turn up of women seeking work.

The Client shall organizes several meetings with the communities and community leaders to provide clear information about the works, explaining that women can participate equally. Show examples and photos of previous labour-based road projects in Timor-Leste demonstrating that women can participate in the works.

During the recruitment process, the Contractor should ensure that women are fully aware of the opportunity to participate in the road work activities and disseminate information about recruitment processes and conditions of work.

However, whether the household participates with men or women, the Contractor and Client will encourage participants to spend their earnings wisely and productively to benefit the household.

The flow of information must reach women! The information shall include:

- + Work opportunity in road work
- + Wage to be paid to women
- + Payment procedure
- + Activities can be done by women

M-1-4 Gender consideration during implementation

During implementation of construction or rehabilitation of the road works, monitoring and reporting are essential to follow up processes and to ensure that activities are being undertaken according to plan including compliance to the contract on gender issues. The contractors must comply with contractual obligations with regards to gender issues pertaining to:

- + recruitment of workers
- + work systems
- + flexibility in working hours
- + provision of special facilities for female workers such as sanitary facilities and shades for kids of working mothers
- + guidelines for labour practices and checklist for regular monitoring of working conditions should be used throughout implementation.
- + a zero-tolerance policy on harassment
- + achieve a minimum target of 30 % women participation in the works

Task Assignment

Certain activities are more suited for women and based on experience women often like to work together in groups. Therefore, as it is important to consider work systems and allocation of activities that will maximize work output, it is recommended that:

- + Women may work together on a group task. They will help each other to complete the task, and when the task for the group is completed they are all free to leave.
- + The following activities are specifically suitable for women:
 - o Clearing grass
 - o Leveling
 - o Sloping and forming camber

- o Spreading gravel
- o Sieving sand
- o Supporting activity like working at the site camp as cook and preparing peg for the setting out team

Flexible Working Hours

Women may not be able to come to work a certain time or may have to return home a certain time to take care of domestic responsibilities. Flexibility in working time should therefore be encouraged and used where possible, except for more complex operations or instances where other activities are dependent on certain inputs at specific times.

The task based work system can facilitate a certain degree of flexibility with regards to working hours, as the workers within reason can choose when during the day to complete their tasks, as long as the contractor can plan and supervise the work in an effective manner.

If the Contractor strive to facilitate flexible working hours, which could also be a combination of task work with time based work, this is likely to attract more women and can help increase productivity.

Provision of Special Facilities for Men and Women

Sanitary facilities are not always provided on labour-based work sites. However, when they are they are provided generally for both men and women. This may result in female workers not wanting to use the sanitary facilities in fear of embarrassment from their male counterparts. In some cases this has been a de-motivating factor preventing women from coming to work or continue working on roads. Contractors must therefore provide separate sanitary facilities for male and female workers.

In order to encourage and support breast-feeding mothers to work, contractors should construct temporary shelters for babysitters and children from sun heat and rain. Contracts may have a provision for including a babysitter on the payroll.

Special attention

The contractors must consider and address gender issue at all stages of implementation, starting from mobilization through recruitment and implementation of the works. The instructions in the tender documents and the conditions of contract documents clearly specify the contractors responsibilities including to:

- + Inform women of employment possibilities and to actually employ as many women as possible
- + Keep gender disaggregated employment records (muster roll) and achieve minimum 30% female participation in the works
- + Provide equal opportunities to women and men and ensure equal pay for work of equal value
- + Provide on the job training of women (if and when required)

M-2 HIV/Aids awareness

HIV is a virus that causes AIDS (Acquired Immune Deficiency Syndrome). HIV destroys the biological ability of the body to fight off opportunistic infections such as tuberculosis. A person can be infected with the virus for a long time without showing any symptoms of the disease. Nonetheless, during that period before the person develops symptoms, he or she can transmit the infection through sexual contact to other, uninfected persons. An infected woman can also transmit the disease to her infant during pregnancy or delivery or while breastfeeding. HIV can also be spread by transfusion of contaminated blood and by sharing needles used for injections and drug use. AIDS itself is defined in terms of how much deterioration of the immune system has taken place as seen by the presence of opportunistic infections. Virtually all infected people will eventually die from the disease, unless they have access to treatment, to so called anti retroviral drugs.

Moreover, HIV/AIDS has still a stigma attached to it which mean that people generally do not like to talk about it, and dealing with the issue may meaning breaking taboos. It is therefore advisable to involve professionals to deal with it. There are a number of government departments and NGOs that have the capacity to carry out adequate awareness campaigns and provide counseling services.

It is usually the Client or government who provides the necessary information about STD's and HIV/AIDS through training and community consultations. However, the contractor is also obligated to provide awareness about STD's and HIV/AIDS to the labour force, to the population living adjacent to the roads and to his own staff as the labour-based approach involves many people either directly by providing job opportunities or by working together with local communities along the roads

Do not hesitate to discuss HIV/AIDS with your staff and labour force. It is an issue that concerns all of us! and should you need professional support, do not hesitate to contact health organisations to assist you in dealing with HIV/AIDS issues.

Summary of Key Principles for Dealing with HIV/AIDS at the Workplace as recommended by the ILO:

-  Treat HIV/AIDS on the workplace like any other serious illness/condition.
-  Do not allow discrimination against persons infected or affected by HIV/AIDS.
-  Ensure gender equality and empowerment of women to successfully prevent the spread of HIV infection.
-  Ensure a healthy and safe work environment to minimize the spread of HIV.
-  Provide opportunities to discuss HIV/AIDS issues and problems with and among your labour force.
-  HIV/AIDS screening is not a requirement for job applications.
-  Disclosure of HIV/AIDS personal information is not allowed. Confidentiality of personal data is compulsory!

- ✚ HIV infection is not a cause for termination of employment!
- ✚ HIV infection is preventable. It can be furthered through changes in behavior, knowledge, treatment and creation of a non-discriminatory environment.
- ✚ Provide support and care to those who are affected. Solidarity with your workers and their dependants is a social obligation.

M-3 Environmental issues

Environmentally sustainable development is high on the international agenda and it is generally noted that, across the donor community and national governments, environmental and other crosscutting issues are now mainstreamed into the development process. Many governments have devised policies and strategies to protect the environment and to reduce the damages on the environment by economic and social development activities. This also applies to the road and transport sectors whose potentially negative effects on the natural and human environment is receiving increased attention.

M-3-1 Mainstreaming environmental issues in LBT road works

Environmental concerns need to be identified before road rehabilitation begins to avoid them cropping up as surprises during the construction phase. Environmental concerns must be considered and addressed throughout the entire construction process from the identification, planning and design stages through implementation, maintenance and operation of the asset.

Planning and preparation

Planning and preparation activities include road prioritization and selection, design, preparation of contract documents and contract procurement. Environmental concerns must be addressed in all these stages as elaborated below:

One of the major preparatory activities for road rehabilitation works is to collect and update road condition data and socio-economic data. Data on environmental indicators should be collected at this stage which can include but not be limited to:

- ✚ Scope and the nature of work in respect to the environment
- ✚ Influence of the work on protected areas (forest reserves, parks), wetland ecosystems, domestic water supply sources, vegetation resources, social environments (houses, public institutions and road usage among others.)
- ✚ Anticipated changes in the drainage pattern, land use pattern, landscape, human settlements along rehabilitated road.
- ✚ Public health impacts: noise levels, dust levels
- ✚ Alternative re-alignments and their environmental implications.

Relevant mitigation measures shall be made part of the prioritization and selection process as this would determine whether a mitigation measure is able to adequately

satisfy environment requirements arising out of works on a selected road. Issues of mitigation costs for the impacts are some of the parameters to take into consideration for prioritization and selection of road construction or rehabilitation projects.

After the selection and approval of roads for rehabilitation, another major planning activity is conducting of detailed surveys and design of the technical works. The design shall incorporate all necessary environmental mitigation measures. Mitigation measures shall be designed and budgeted for by the Engineer, if necessary with the participation of other environmental experts. Attempts shall be made to involve the local people in the process to make use of the local knowledge.

Awareness raising

After selection of roads for rehabilitation, mobilization will follow. Awareness on “environment issues in road works” shall be conducted as an integrated part of community meetings during **Mobilization Meeting** before the commencement of road works. Awareness shall also take place through other mobilization campaigns at the community levels.

Contract Procurement

Bidders shall be made aware of environmental issues during the contract procurement process through the pre-tender meeting and site visit. The site visit provides an opportunity for investigation of availability of and access to construction materials and labour, safe water source, identification of the camp site location and availability of storage facilities, drainage issues and potential erosion problems and any other environmental issues related to the planned road works. This to ensure that the bidder is well prepared and understands the environmental issues before finalizing his or her bid.

M-3-2 Environmental mitigation measures during road construction

During road rehabilitating works, there are a number of environmental impacts, some of which are temporary and others are permanent. Many of the impacts are a result of how the work is executed. In all, negative impacts can be avoided or reduced by making provision for mitigating actions during planning and design stage in road rehabilitation process. Some of the examples of temporary negative impacts may include:

-  Dust from haulage vehicles
-  Sound pollution from equipment
-  Overexploitation of water sources by use for road construction
-  Pollution of water sources from oil spills

In addition to the above there are some of the common environmental problems can be addressed during the LBAT road rehabilitation/ construction:

Environmental mitigation for establish and demolish site camp

The establishment of site camps can leave an environmental footprint if not carefully managed. Care shall be taken during establishing and removing the site camp:

- ✚ Camp shall not be located near settlements or near drinking water supply intakes or to negatively impact local resident's access to drinking water. Camps shall not be in the vicinity of landslides and flood plains.
- ✚ The camp shall be operated within a self sufficient infrastructure. No trees shall be cut for firewood and removal of vegetation shall be minimized. To prevent local inflation and use of local fuel-wood supplies. Critical food items and alternate fuel for cooking shall be provided by the contractor. (Local people should be given the option to sell surplus food and fuel-wood to the contractor if these items are in surplus and if the extraction of these resources is sustainable during the period of the project). The contractor shall prohibit employees from poaching wildlife and cutting trees. The contractor will be responsible for the action of their workers.
- ✚ Water and sanitation facilities shall be provided for employees. In water deficient areas, the contractor shall haul water from a source outside the area. Solid waste shall be managed according to the following preference hierarchy; recycling, burial or burning.
- ✚ Used oil and lubricants shall be recovered and reused or removed from the site by the contractor. Explosives oil, petrol, and grease shall be managed according the Explosives Management provision guidelines. Solid waste shall be managed according to the following preference hierarchy; recycling, burial or burning. When feasible, local residents shall be encouraged to scavenger non-hazardous solid wastes that are no longer usable to the project.
- ✚ At end of the contract all wreckage, rubbish or temporary works shall be removed. All temporary structures including sleeping quarters cooking and food storage structures and latrines shall be removed to prevent encroachment within the road right-of-way. The site shall be restored to near natural or stable conditions. The Engineer shall report in writing that the camp has been vacated and restored to pre-project conditions.

Environmental mitigation when taking borrow pits

Extracting materials for road construction such as gravel, sand and stones will leave scars in nature. A quarry or borrow pit will disruption of natural land contours and vegetation resulting in accelerated erosion, disturbance in natural drainage patterns, pounding and water longing and water pollution.

In order to minimize the negative impact of borrow pits and quarries the following mitigating measures should be implemented:

- ✚ Some borrow areas can be extensive sometimes covering up to one acre in size, thus taking up land for crop production. To reduce on loss of agricultural land, the opening of land should be limited to necessary areas for the pit and route alignment.
- ✚ Stripped material shall be stored so as to not disrupt natural drainage and shall be protected so as to not be eroded into surface waters.
- ✚ Topsoil shall be stored in specific piles and the utilization of excess topsoil shall be discussed with local resident. The pounding of surface water shall be prevented through adequate drainage.
- ✚ Keep all the vegetation material on the site (grass, shrubs and possibly tree materials). This should be stockpiled aside near the pit.
- ✚ Also the subsoil materials be stockpiled separately once excavated. After extracting the material, the area should be restored as follows:
 - All unused material should be placed back in pit as the first layer of material in the base of the pit.
 - The subsoil material should then be placed back and evenly spread over the boulder materials.
 - The top soil is eventually returned and spread over.
 - The sides of the pit are trimmed giving a gentle slope (eliminating the sharp cliffs).
 - Leveling should ensure surface water run off, water collection in the pits should drain naturally in order to reduce incidence of disease vectors.
 - In order to enhance regeneration of vegetation, sods of grass for instance, can be planted on the site.
- ✚ Site restoration works shall be conducted before equipment or labour is allowed to leave the site. The Engineer shall report in writing that the necessary

environmental restoration work has been adequately performed before acceptance of the works.

- ✚ Depending on the land owner, it is advisable to plant some trees on the site especially, when the site is extensive to facilitate the area to blend well with the adjacent areas.

Environmental mitigation for taking material Quarries

Quarry for the collection of gravel, sand or stone will disrupt of natural land contours and vegetation resulting in acceleration erosion, landslides, disturbance in natural drainage patterns, siltation of surface waters and water pollution. General sourcing of river beds resulting in endangerment of bridges and continuous degradation of the river regime. Care must be taken when carrying using the quarry:

- ✚ It is the contractor's responsibility to verify the suitability of all material sources and to obtain the approval of the Engineer.
- ✚ Quarry sites are to be located away from population centres, drinking water intakes and streams, cultivable lands and natural drainage systems. Quarries shall be located in structurally stable areas even if some distance from construction activities.
- ✚ The cutting of trees and removal of other desirable vegetation shall be avoided. Stripped material shall be stored so as to not disrupt natural drainage and shall be protected to prevent erosion and migration of soil particles into surface water. Temporary ditches or settling basins shall be dug to collect runoff water and to prevent erosion and contamination of surface water. The undesirable ponding of water shall be prevented through temporary drains discharging to natural drainage channels.
- ✚ The quarry site should be restored after construction activities have finished. The site shall be left in a stable condition, without steep slopes. Stripped material shall be spread to stable contours in order to stimulate percolation and re-growth of natural vegetation and natural drainage. The site shall be drained and no standing water shall remain.
- ✚ Land utilized for river bed extraction and quarry site access roads shall also be restored. Exposed areas shall be rehabilitated with suitable vegetation at the earliest opportunity and the Contractor shall follow the instruction of the engineer responsible. Site restoration works shall be conducted before spreading equipment or labour is allowed to leave the site. The Engineer shall report in writing that the necessary environment restoration work has been adequately performed before acceptance of the works.
- ✚ Extraction of rocks, gravel and sand from small rivers or streams shall be discouraged. If extraction is necessary then the extraction point shall be spread out along the length of the river to minimize disruption in river flow and to prevent instability to embankments. Extraction point shall not be near bridge or river training structures. The depth of material removal at any one location shall

be limited and extraction area shall be selected where there is little fine material to be carried downstream. Local residents and water users shall be consulted to ensure that irrigation intakes, bunds and local fishing are not adversely impacted.

Environmental mitigation when carrying out bush clearing and tree cutting for road works

Bush clearing and cutting trees should be done carefully. Clearing should be done only within the width of road formation. Tree and bushes which are grown outside of the road formation should not be cut. During this operation, care should be taken as follow:

- ✚ Larger trees should only be cut after consultation with the engineer and care should be taken when cutting trees to avoid injury to workers or property
- ✚ Vegetation and other debris that has been cut should be removed from the road formation and disposed of in a proper place as instructed by the engineer.
- ✚ Burning of cut vegetation next to the road side should be avoided as it is an environmental hazard. Uncontrolled burning may cause accidents and loss of property and smoke may also impair vision leading to traffic accidents.
- ✚ depressions caused by uprooting large tree stumps (if they fall outside the formation width) should be backfilled.
- ✚ debris or spoil material may be discharged to a landfill. If feasible spoil material may be disposed of in an abandoned quarry or borrow pit as means to help restore original contours.
- ✚ care should be taken so that stones and boulders from this activity do not block natural waterways or diverts them
- ✚ Realignment of the road should be avoided if possible. However it is often necessary to widen the road footprint to install side drains for example. Adequate warning should be given in good time to land owners with crops on the areas to be affected by a realignment or road widening in order to reduce loss of crops.

Environmental mitigation when carrying out earth work construction

Negative impacts as a result of earth works operation include accelerated erosion resulting in slope instability, landslides, destruction of vegetation and property, siltation of surface water and water pollution. Care must be taken when carrying out earth work construction:

- ✚ Where material has been extracted from side-borrow outside the formation width, it must be rehabilitated to avoid ponds of water and/or possible erosion.

Edges should be trimmed into gentle slopes and eroded channels shall be backfilled and restored to natural contours.

- ✚ If cut to spoil, the material dumped should be spread out and not left in heaps.
- ✚ The waste material from the back slope must be evenly spread at the disposal area so as not to cause erosion
- ✚ Slopes shall be planted with appropriate vegetation, eg Tali Balanda or other suitable plants, to prevent the erosion protection.
- ✚ All areas susceptible to erosion shall be protected by either temporary or permanent drainage works.
- ✚ In areas of high altitudes and in hilly areas where hills are cut, resulting open surfaces are prone to erosion. Slopes should if possible be trimmed to at least 45 degrees and grass should be planted on the cut surface. When established, the grass forms good cover on open cut surfaces by growing downwards towards the road. Another method that can be used could be to form steps on the open cut surfaces (benching).

Environmental mitigation for use of Bitumen for the road rehabilitation

There is a major risk for deforestation resulting from use of fuel-wood to heat bitumen release of bitumen into the environment. Care shall be taken during using the bitumen:

- ✚ The contractor are encouraged to use bitumen emulsion where feasible. In hilly areas with steep road gradients, cut- back bitumen shall be use,
- ✚ Use of fuel-wood for heating bitumen shall be discouraged. Where heating is required bitumen heaters shall be used, fuelled by kerosene, diesel or gas.
- ✚ Bitumen shall not be applied during strong winds and rain periods or if rain is likely. No bituminous material shall be discharged into side drains. Nearby trees, vegetation and private property shall be protected during bitumen spraying work.
- ✚ Bitumen drums shall be stored designated locations and not scattered along the road

M-4 Occupational Safety and Health (OSH)

M-4-1 Safety and health office

The Contractor shall for each work site appoint one staff to be the designated safety and health officer. The Contractor will appoint a technically competent staff member to responsible for this purpose. No site should ever be left without a designated safety and health officer, even for a short period of time. It is the duty of the safety and health officer to ensure that all the safety and health regulations and procedures are followed, and the required safety gear and other equipment required is made available.

M-4-2 Safety at work

The engineer can assist in the prevention of accidents and thereby improve overall work performance through the following methods:

-  Effective communication: Communicating effectively with the work force on accident prevention is often the key to a successful approach to safety improvement.
-  Use of safety equipment: Make sure that safety equipment is available when and where it is needed, insist that it is always used and take disciplinary action against workers who refuse or frequently forget to use the equipment. (E.g. safety goggles, hard hats, gloves, boots and ear protectors.)
-  Record keeping: Keeping records of the types of accidents that occur most frequently, and why they occur; this makes prevention easier, as the primary causes of accidents will become known.

M-4-3 Examples of Accidents

Accidents may occur in a number of ways. Some examples are:

-  Falling objects, tools or building materials, etc
-  During the felling of trees.
-  During loading, unloading, lifting, carrying and transporting loads on or in connection with vehicles of all kinds.
-  By combustible, hot or corrosive materials.
-  By dangerous gases.
-  When using hand tools.
-  By stepping on sharp objects.
-  The use of heavy equipment combined with the threat of falling material constitutes a risk situation and labourers must be well-spaced to avoid injury.

M-4-4 Causes of Accidents

In the following list, the causes of accidents have been grouped together according to their nature:

- ✚ Defects in technical planning. For example, a trailer carrying rollers from a site has a puncture on one tyre. If planning rules are not strictly enforced (including having penalties for disregard) the driver might be tempted to change the wheel without first off-loading the heavy rollers. This situation would endanger any persons near the trailer, especially if the jack which is used to raise the trailer fails for any reason.
- ✚ Insufficient or defective supervision of the work.
- ✚ Lack of co-operation between different trades.
- ✚ Construction defects
- ✚ Use of unsuitable materials
- ✚ Defective processing of materials.

Equipment

- ✚ Unsuitable equipment
- ✚ Defects in equipment
- ✚ Lack of safety devices or measures
- ✚ Unskilled or untrained operators
- ✚ Working under the influence of alcohol or drugs
- ✚ Inadequate examination of equipment

Management and conduct of the work

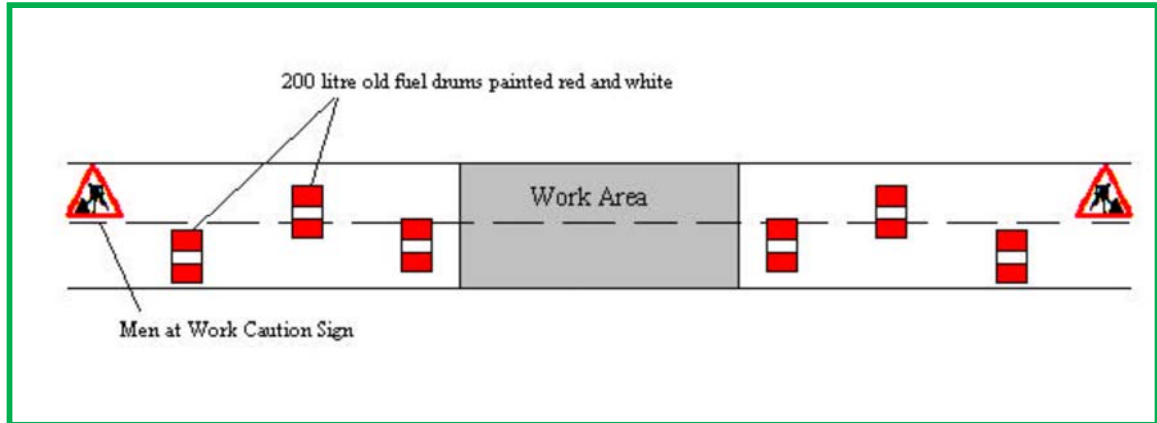
- ✚ Inadequate preparation of the work
- ✚ Imprecise or inadequate instructions from supervisors
- ✚ Inadequate supervision.
- ✚ Irresponsible acts e.g.
- ✚ Carelessness. e.g. Allowing children on site

M-4-5 Safety on Site

Below are some guidelines, which should be followed, regarding safety on site.

- ✚ Any project personnel working on a work site must wear a safety gear where advised to do so. This includes setting out workers, skills and un-skills workers, mason.

- ✚ Children are not allowed on the work site, at any time. This rule applies to all sites, including routine maintenance activities.
- ✚ All work sites should have clear safety signs and traffic control devices to reduce vehicle speed.



- The area/section of the road under repair should be clearly marked off with either flagging tapes or red-white cones (reflective)
 - Speed regulating devices (such as rumble humps) of earth should be erected at 100 m intervals for 200 m distance before the site to reduce speed of vehicles
 - Road workers should be briefed regularly of the dangers related to roads open to traffic
 - The section being open to traffic should be clear off all road equipment and construction materials
 - Work cannot proceed unless sufficient safety signs and traffic control devices are available. Barriers should be laid out above.
- ✚ All stores and offices should have at least one chemical fire extinguisher mounted on the wall 'outside' the door. The extinguisher(s) should be checked every day. Empty or partially used extinguishers should be refilled immediately. All store personnel, operators, drivers, administration and technical staff should know how to use a fire extinguisher
 - ✚ All equipment should be checked daily to ensure that all measures have been taken to make it safe for operation. All trucks should be road-worthy and each truck should be examined by a qualified mechanic every month. All defects should be remedied immediately, and truck should be operated if any safety features are defective.
 - ✚ All equipment and material carried in any vehicle must be secured properly. Rollers must be secured with chains. Materials must be secured with ropes or chains, as necessary. Fuel and water containers should be secured properly, even when empty. Water bowser tanks must be secured properly to the chassis of the truck, not the wooden frame. These connections must be checked regularly.

- ✚ All cars should have seatbelts fitted front and rear. The seat belts should be of the type which cross diagonally across the body, as well as across the waist. All drivers and passengers must wear seatbelts at all times while the car is moving. All cars should have first aid kits, and all drivers should have undergone a first aid training course. It is the drivers' duty to ensure that all passengers are wearing seat belts.
- ✚ All motorcycle riders should wear safety helmets, regardless of the distance being travelled. Only two persons should be allowed on a motorbike. All motorcycles should be checked at least once per month.
- ✚ When drivers are reversing truck they should be assisted by another person, to ensure that no persons are behind the truck. Water bowsers should never reverse down a road while spraying water.

M-4-6 Health at work

A healthy worker is a productive worker...

Remember

A well stocked first aid kit **MUST** be available on site to treat minor injuries immediately.

The Contractor shall provide all workers with safe drinking water. One or two workers may be recruited for this purpose. They may carry water from source to the workers along the work site.

To sprinkle water when the road is dusty to avoid effect the health of the worker and the people live in vicinity avoiding traffic accident cause by dust.

LBT Training Manual

Module N

Reports and Site Administrative Forms

Table of Contents, Module N Site Administrative Forms

N Reports	3
Employment Registration Form	6
Muster/Payroll	7
Overall/Daily site planning and actual record	8
Weekly / Monthly report	9
Monthly Progress Report	10
Monthly Work Plan & Physical Progress.....	11
Fuel Distribution Record	12
Fuel Stock Record.....	13
Tools Stock Record	14
Site Equipment Log Book	15
Materials delivery control sheet	16
Quantities Earth Work and Gravel.....	17
Quantities Structures	18

N Reports

Careful reporting is important for effective and efficient management of construction activities for both the contractor and the client. The reporting is important to ensure that the activities have been carried out to the correct quality with the planned resources and at the right time as well as to control cost and quality.

When reports are analyzed it should be clear if and why the targets are (not) reached, and with this feedback, better planning can be done next time. The production reports also give an opportunity to analyze a very good performance, i.e. when the targets have been exceeded. Well kept and accurate reports are also an indication of the ability of the supervisor. An accurate daily report cannot be made unless the writer knows very well how the site is organized and has taken place during.

As with planning, reports can be classified. Systems of classification can be based on time (daily and weekly), activity (soil excavation, clearing, gravel spreading, stone packing, foundation excavation, culvert installation) or items (hoe, pickaxe, crowbar, etc). The Engineer will usually have to deal with all of these types of reports.

Flow of Progress Reports

The flow of reports from the site to company's office usually follows the formal line of communication. The supervisor reports to the site engineer and the site engineer to Contractor's director.

Control

Controls are made at all levels and have different purposes (cost control, production control, etc.). At site level, production control is essential to keep track of the inputs and outputs (work-days and quantity of work completed).

Control is necessary to check whether the work progresses according to plan. If this is not so, a property carried-out control will show where the mistake lies. Wrong assumptions may have been made in the planning of the work, the organization may not be correct or the actual execution of the work may be poor. The job of the supervisor is to find out what went wrong and for what reason and to do something about it!

The more often controls are made, the less can go wrong and the easier it is to correct. Work is controlled at all levels in the project, from site to main office. Different types of control exist:

-  quality control,
-  production control,
-  number of Work Days (wd) control.

At the site level, the production and quality controls are most important. Production control mainly involves two things:

- ✚ the input (the quantity of works, number of work days, amount of materials, etc.),
- ✚ the output (the quantities of work done, i.e. square metres of clearing or cubic metres of excavation, length of pipe culvert installations).

In order to control the progress accurately, a control activity is usually monitored. The tools for control are:

- ✚ inspections;
- ✚ records of other expenditure;
- ✚ reports;
- ✚ muster roll.

Reports are control tools which allow Engineer to see what has happened on the site. This report and control allows the Engineer prepares better and more accurate planning.

N-1 Required reports

It is absolutely essential to use planning and reporting forms to maintain control of work activities. However, make sure to use only the very necessary forms which provide you with the information to plan and control your work. The reports below is the minimum requirement in terms of reporting on labour-based projects.

N-1-1 Daily Site Progress Report

The daily site progress report allows the contractor to plan on a daily basis the activities to be carried out, to record the actual achieved quantity of works and to calculate the required input in terms of labour both for formation works and gravelling. The form has to be filled by the Site Supervisors in charge of the site while the Contractor checks/approves it.

The daily reports give information to the Engineer who planned the work. When Engineer has analyzed the figures it should be clear if and why the targets are (not) reached. Either the targets have not been set correctly or the work has not proceeded as planned. With the information of the report, better planning can be done for next day.

An accurate daily report cannot be made unless the Engineer knows very well how the site is organized and has taken place during that day.

N-1-2 Weekly Progress Report

This form summarizes the information on actual production from the Daily Site Report. The Weekly Report is prepared at the end of each week.

The Weekly Report contains all activities the Engineer needs to report. Enter the output recorded under "ACTUAL" in the Daily Report into the appropriate columns of Quantity of works and Work Days of each activity and each day in the week of weekly report.

N-1-3 Monthly Progress Report

The monthly progress report allows the contractor to summarize the monthly work progress and worker-days used for the road activity. The form has to be filled by either the Site Supervisors in charge of the site while the Contractor checks/approves it. A signed copy of this form has to be submitted to the Client.

The monthly site report is prepared at the engineer's office at the end of the month. Items of interest to Offices are described as required. Examples of such items are: calculation of total (output, average productivity achieved, expenditures, etc.). The progress of the work, i.e. the position of the control activity, is plotted on the planning graph. This is done by drawing a line from the previous point (last month's position of the control activity) to the one for the month concerned. This will show if the actual productivity and production.

N-1-4 Muster Payroll

The muster payroll is the labour record that records the recruited labour and the actual labour attendance. This is the base for labour payments. The contractor has to maintain and update the muster payroll on a daily basis as stipulated in the conditions of contract. A signed copy of this form has to be submitted to the Client on a monthly basis, as part of the payment claim by the contractor. The contractor must also ensure that laborers sign for payment received on the muster payroll.

N-1-5 Store Records

Store records are essential to record all materials and tools received and issued at site. The system has to allow for recording the tools issued to individual labourers and the materials spent for each work site, eg structure sites. Other consumables, like petrol, diesel, oil etc must also be recorded. These records are important to control costs and to avoid misuse.

N-1-6 Equipment Records

Besides the equipment log books where the movement and consumption of fuel plus service details are recorded, no other records are necessary to keep track of the equipment usage details. However the equipment operations on site must be planned together with the manual activities (and included in the daily and weekly site plans etc)

Employment Registration Form

Contract Code					
Road Name					
Name of Worker					
ID Number					
Place and Date of Birth		____/____/____		Age: (>15) __ __	
Home address		District			
		Sub-district			
		Suku			
		Aldeia			
Sex	☐ Feto ☐ Mane	Civil status	☐ Kaben Nain ☐ Viuva/u/Faluk	☐ Divorsiu/Soe malu ☐ Klosan/Soltero	
Profession	☐ La-servisu Estudante	☐ Servisu iha sektor:	☐ Hotel/Restaurante ☐ Fa'an sasan ☐ Manufaktur ☐ Agricultura/peska ☐ NGO ☐ Transporte ☐ Fo servisu ☐ Kostrusaun ☐ Elektrisidade ☐ Servisu ba han rasik		
Education	☐ La-eskola ☐ Primaria ☐ Pre-sekundaria ☐ Sekundario ☐ Tekniku-preparatoriu ☐ Ensinu Superior				
Vocational Training	☐ Seidauk ☐ Tuir ona	Area of training		Name of Training Provider	
Name Supervisor					
Date of registration	____/____/____		Signature		

Muster/Payroll

District name:										Road Name:										Suko:									
Contract No:										Section of this contract Ch: to Ch:										From / / To / /									
Contractor:										Name of Contractor's Supervisor										Page no: of									

No	Full Name	Sex		Muster-Roll																Actual WD		Wage rate. USD	Amount paid. USD	Payroll	
		M	F																					Signature/Finger Print	
		Day->																M	F						
1																									
2																									
3																									
4																									
5																									
6																									
7																									
8																									
9																									
10																									
11																									
				Total																		Total			

Date: / / Name: Signature: Contractor's Supervisor	Date: / / Name: Signature: Contractor's Director	Date: / / Name: Signatur Chefe Suko
---	---	--

Overall/Daily site planning and actual record

OVERALL / DAILY SITE PLANNING AND ACTUAL RECORD

District:.....

Sucu:.....

Road Name:..... Length:.....km

Weather:.....

PLANNED							ACTUAL / ACHIEVEMENT						Actual norm	
ACTIVITIES	Unit	Km-Start	Km-End	Output	Norm	No Labour	ACTIVITIES	Unit	Km-Start	Km-End	Output	No Labour		
1- Earthworks							1- Earthworks							
Setting out	m						Setting out	m						
Bush and grass clearing	m ²						Bush and grass clearing	m ²						
Cut trees & stump removal	no						Cut trees & stump removal	no						
Soil excavation / Cut	m ³						Soil excavation / Cut	m ³						
Leveling	m ³						Leveling	m ³						
Ditching	right	m ³					Ditching	right	m ³					
	left	m ³						left	m ³					
Sloping	right	m ³					Sloping	right	m ³					
	left	m ³						left	m ³					
Forming camber	m ³						Forming camber	m ³						
Embankment / Fill	m ³						Embankment / Fill	m ³						
Excavation of mitre drain	m						Excavation of mitre drain	m						
Watering / compaction	wd						Watering / compaction	wd						
Other							Other							
2 - Gravelling Works							2 - Gravelling Works							
Reshaping subgrade	m ²						Reshaping subgrade	m ²						
Excavation of gravel	m ³						Excavation of gravel	m ³						
Haul gravel by wheelbarrow	m ³						Haul gravel by wheelbarrow	m ³						
Spreading gravel	m ²						Spreading gravel	m ²						
Surface improvement	m						Surface improvement	m						
Watering / compaction	wd						Watering / compaction	wd						
Other							Other							
3 - Structures							3 - Structures							
Culvert construction	No						Culvert construction	No						
Lined drain	m						Lined drain	m						
Retaining wall	m						Retaining wall	m						
Gabion	Box						Gabion	Box						
Supporting & gang leader	wd						Supporting & gang leader	wd						
Total WD							Total WD							
Prepared by:..... Date:...../...../2014							Checked by:..... Date:...../...../2014							
Supervisor							Engineer							

Weekly / Monthly report

WEEKLY/MONTHLY SITE REPORT

District:.....

Sucu:.....

Road Name:.....

Length:.....km

DATE		Month:2013										Total this month				
ACTIVITY	Unit	qu-ty	Wds	qu-ty	Wds	qu-ty	Wds	qu-ty	Wds	qu-ty	Wds	Chainage		Total		
												Start	End	Quantity	Wds	
1- Earthworks																
Setting out	m															
Bush and grass clearing	m ²															
Cut trees & stump removal	no															
Soil excavation / Cut	m ³															
Leveling	m ³															
Ditching	right	m ³														
	left	m ³														
Sloping	right	m ³														
	left	m ³														
Forming camber	m ³															
Embankment / Fill	m ³															
Excavation of mitre drain	m															
Watering / compaction	wd															
Other																
2 - Gravelling Works																
Reshaping subgrade	m ²															
Excavation of gravel	m ³															
Haul gravel by wheelbarrow	m ³															
Spreading gravel	m ²															
Surface improvement	m															
Watering / compaction	wd															
Other																
3 - Structures																
Culvert construction	No															
Lined drain	m															
Retaining wall	m															
Gabion	Box															
Supporting & gang leader	wd															
Total WD																
Prepared by:..... Date:...../...../2014												Total Wds:				
Supervisor												Male:				
												Female:				

Monthly Progress Report

MONTHLY PROGRESS REPORT			SUMMARY PHYSICAL ACHIEVEMENT					
			For the Month of 2014					
ROAD REHABILITATION		Unit	Road name:				Length (Km):	
			Cumul. to last month		This month		Cumulative Total	
			Quantity	WD	Quantity	WD	Quantity	WD
1- Earthworks								
Setting out		m						
Bush and grass clearing		m ²						
Cut trees & stump removal		no						
Soil excavation / Cut		m ³						
Leveling		m ³						
Ditching	right	m ³						
	left	m ³						
Sloping	right	m ³						
	left	m ³						
Forming camber		m ³						
Embankment / Fill		m ³						
Excavation of mitre drain		m						
Watering / compaction		wd						
Other								
2 - Gravelling Works								
Reshaping subgrade		m ²						
Excavation of gravel		m ³						
Haul gravel by wheelbarrow		m ³						
Spreading gravel		m ²						
Surface improvement		m						
Watering / compaction		wd						
Other								
3 - Structures								
Culvert construction		No						
Lined drain		m						
Retaining wall		m						
Gabion		Box						
Supporting & gang leader		wd						
TOTAL WD								

Monthly Work Plan & Physical Progress

Monthly Workplan & Physical Progress for the Month of.....

Road Name:.....

District:

Section: No.....

Date:

Total Road Length:.....

Total Quantity					2014						Percent. complet.
	Unit	Plan	Actual		Mar	Apr	May	Jun	Jul	Aug	
Earthworks	km			Plan							
				Actual							
Gravel	km			Plan							
				Actual							
Lined drain	m			Plan							
				Actual							
Culverts	no			Plan							
				Actual							
Drift	no			Plan							
				Actual							
Gabion	Box			Plan							
				Actual							
Cumulative Up to This Month											
	Unit	Plan	Actual		Mar	Apr	May	Jun	Jul	Aug	
Earthworks	km			Plan							
				Actual							
Gravel	km			Plan							
				Actual							
Lined drain	m			Plan							
				Actual							
Culverts	no			Plan							
				Actual							
Drift	no			Plan							
				Actual							
Gabion	Box			Plan							
				Actual							
Remark:											
Actual:											
Planned:											

Date:...../.....2014

Prepare by:

Site engineer

Fuel Stock Record

REGISTRO BA IHA STOK COMBUSTIVEL

Ba fulan:.....

Estrada:.....

Distrito:.....

Loron/data:.....

<i>Deskrisaun</i>	<i>Transitado</i>	<i>Simu iha fulan ida ne'e</i>	<i>Uza ona iha fulan ida ne'e</i>	<i>Fulan ne'e lakon hira</i>	<i>Transitado ba fulan oin</i>	<i>Remarks</i>
Gazoel						
Gasolina						
Oli mesin						
Masa						
Oli Hydraulic						
Oli Travaun						

Preapara husi official kampu

Verifika husi: Egenheiro de Kampu

Tools Stock Record

Ba fulan:.....
 Estrada:..... Distrito:..... Loron/data:.....

<i>Deskrisaun</i>	<i>Transitado</i>	<i>Simu iha fulan ida ne'e</i>	<i>Hasai iha fulan ida ne'e</i>	<i>Feramentas ne'ebe at iha fulan ida ne'e</i>	<i>Feramentas ne'ebe lakon ida ne'e</i>	<i>Transitado ba iha fulan oin</i>	<i>Remarks</i>
Ensada							
Kanuru bo'ot							
Karau dikur							
Garfu							
Bow saws							
Balku							
Katana lere du'ut							
Karosa							
Padiola							
Raga / bote							
Escopu							
File (S)							
File (M)							
Metro bo'ot (30m)							
Metro badak (5m)							
Ranging rods							
Profile boards							
Line levels							
Martelu 1kg							
Martelu 3kg							
Ai-suak							
Ai-suak – 80cm							
Ai-suak – 150cm							
Tali							
String line							
Sharpening stones							
Luvas							
Kanuru bo'ot (belar)							
Kado'o bo'ot							
Bidon							
Bomba mina							
Balde							
Jerigen							
Jerigen rega							
Hand rammers							
Feramentas ulun (pegangan)							

Preapara husi official kampu

Verifika husi: Egenheiro de Kampu

Tipu de ekipamentu:..... Kapasidade:..... No. registu ou no. sapa:.....

Estrada:

Distrito:

Sub-Distrito:

[illegible]

Prepara husi:
Operador

Verifika husi:
Ofisial do Kampu

Sertifika husi:
Engeñeiro Local

Materials delivery control sheet

Materials delivery Control Sheet (one control sheet for each truck)

Contractor: <i>Libra</i>		Contract No: <i>ERA-SC-12-0228</i>		Contract Name: <i>Lauana-Leimea Leten Section 01</i>		District: <i>Ermera</i>		
Sub-contractor: <i>Materials Lda (1)</i>		Material, source (km): <i>Stone, Cailaco River 15km</i>		Planned qty/trip: <i>2.5 m3</i>		Planned qty per day: <i>25m3</i>		
Date (fill even if no supply)	Time	Truck dimension (average height of load)			Qty (m3)	Driver Signature	Supervisor Signature	Breakdown Rain, etc
		Length	Width	Height (aver.)				
<i>1-Jul-13</i>	<i>8.3</i>	<i>3</i>	<i>1.5</i>	<i>0.5</i>	<i>2.25</i>	<i>Jose</i>	<i>Phedro</i>	
<i>1-Jul-13</i>	<i>10.3</i>	<i>3</i>	<i>1.5</i>	<i>0.4</i>	<i>1.8</i>	<i>Jose</i>	<i>Phedro</i>	
<i>1-Jul-13</i>	<i>13.15</i>	<i>3</i>	<i>1.5</i>	<i>0.3</i>	<i>1.35</i>	<i>Jose</i>	<i>Phedro</i>	<i>Rain</i>
<i>2-Jul-13</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>Jose</i>	<i>Phedro</i>	<i>Rain</i>
<i>3-Jul-13</i>	<i>8.3</i>	<i>3</i>	<i>1.5</i>	<i>0.6</i>	<i>2.7</i>	<i>Jose</i>	<i>Phedro</i>	
<i>3-Jul-13</i>	<i>10.2</i>	<i>3</i>	<i>1.5</i>	<i>0.5</i>	<i>2.25</i>	<i>Jose</i>	<i>Phedro</i>	
<i>3-Jul-13</i>	<i>12.45</i>	<i>3</i>	<i>1.5</i>	<i>0.5</i>	<i>2.25</i>	<i>Jose</i>	<i>Phedro</i>	
<i>3-Jul-13</i>	<i>14.3</i>	<i>3</i>	<i>1.5</i>	<i>0.4</i>	<i>1.8</i>	<i>Jose</i>	<i>Phedro</i>	
<i>3-Jul-13</i>	<i>16</i>	<i>3</i>	<i>1.5</i>	<i>0.5</i>	<i>2.25</i>	<i>Jose</i>	<i>Phedro</i>	
<i>4-Jul-13</i>	<i>8,30</i>	<i>3</i>	<i>1.5</i>	<i>0,5</i>	<i>2.25</i>	<i>Jose</i>	<i>Phedro</i>	
<i>4-Jul-13</i>	<i>11</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>-</i>	<i>Jose</i>	<i>Phedro</i>	<i>Breakdown</i>
9 trips/4 days	summary no of trips / no of days				18.9 m3	summary quantity		

Quantity **survey** sheet for road Rehabilitation / Periodic maintenance (Annex 1)

[illegible]

Quantity survey sheet for Drainage structures and Proction works (Annex 2)

District:					Chaiange start:										Page no: of pages														
Road name:					Chaiange end:										Date:														
Section length:																													
No.	Chainage		Existing structure		Proposed strcuture, size and Quantity																						Remarks		
					Box Culvert with stone masonry wingwalls (No)			Gabion works (M ³)		Stone masonry works												Other works							
	Retaining Wall (M)									Lined drain with Reta. Wall (M)						Lined drain (M)		Volume Stone Masonry (M3)		Concrete slab for road surface (M)	Other to specify								
Km+	m	Type	Size (M)	1.5x 1.2x5m	1.0x 1.0x 5m	0.8x 0.8x 5m	Down stream	Up stream	H=0.60m	H=0.80m	H=1.0m	H=1.2m	H=1.5m	H=2.0m	H=0.60m	H=0.80m	H=1.0m	H=1.2m	H=1.5m			0.44m ³ /m	0.31m ³ /m	Retai. Wall m ³	Lined Drain m ³				

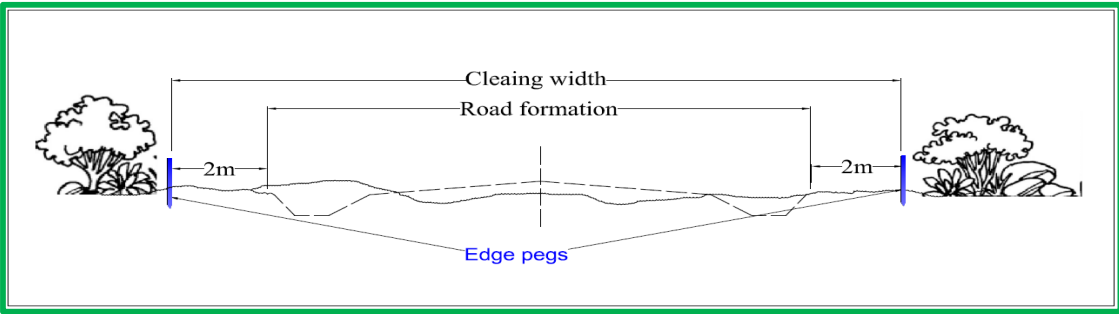
LBT Training Manual

Module 0

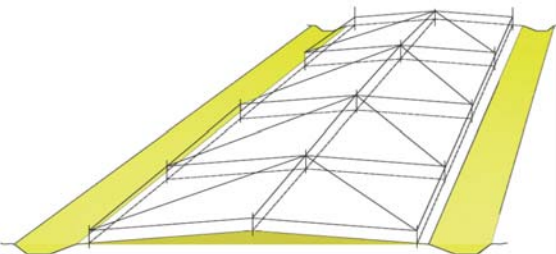
Work Sheets

Work Sheets

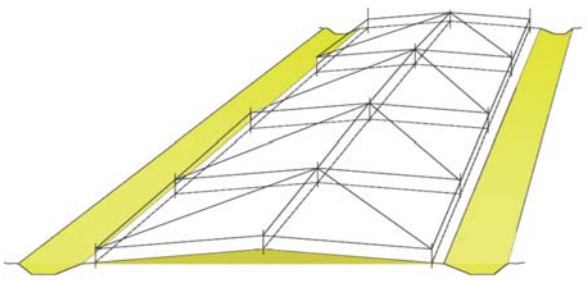
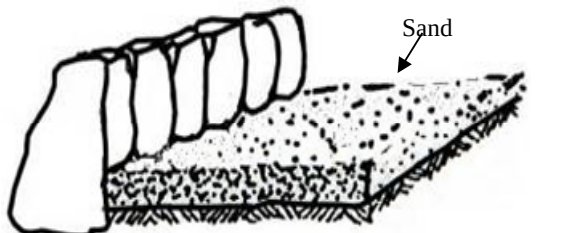
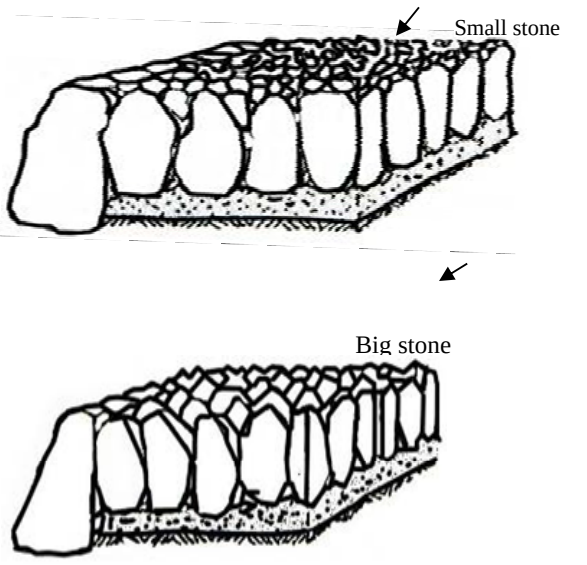
- 1) Site clearing / bush and grass clearing
- 2) Filling sub-Base selected class C material (or natural gravel)
- 3) Telford base
- 4) Road base course with different stone sizes (Macadam)
- 5) Base course with selected class A material (crushed aggregate mixed with aggregate dust)
- 6) Pothole patching
- 7) Prime Coat
- 8) Penetration Macadam Pavement
- 9) Sand Seal Pavement
- 10) Road shoulder repair
- 11) Filling base course (use steel shutter system)
- 12) Prime coat using bituminous emulsion
- 13) Cold mix asphalt (manual mixing of asphalt)
- 14) Cold mix asphalt (using concrete mixer)
- 15) Modified Otta Penetration Seal
- 16) Emulsion Treated Base (ETB)
- 17) Stone masonry work
- 18) Stone masonry lined drain

	WORK SHEET
Site clearing / bush and grass clearing	WS-01
Specification: Before actual road work activities can start, the road section must be cleared from vegetation. Clearing work consists of the removal of trees, bushes, other vegetation, rubbish and all other superfluous material including the disposal of all material resulting of the grubbing. For new road construction, the road alignment shall be adjusted where possible to minimize the destruction of trees and no tree of more than 0.5 meter girth shall be cut without the approval of the contract supervisor. All debris shall be stored and disposed of in a manner acceptable to the contract supervisor.	
Work Method: • Set out pegs for the clearing width at 10 m intervals between pegs. Use centre line pegs as reference. Tie a string along the set pegs. • Clear all existing bush, grass and rubbish within the road section width set by the pegs. • All roots, grass, tree, bushes, debris and big stones have to be removed and deposed out of the road formation or as directed by the contract supervisor. • Areas to be cleared as shown in the drawing or as instructed by the contract supervisor. • If rocks located in the carriage way are too big, heat the rocks with fire, and pour water to break the rocks into smaller pieces. Then remove the pieces from the road carriage way.	
	

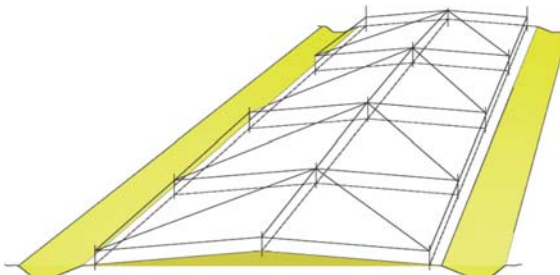
Manpower: • 1 Supervisor (part time) • 2 Workers for setting out (part time) • 1 Work gang for bush clearing • 1 Work gang for clearing grass • 1 Work gang for grubbing	Tools + Equipment: • Tape measures, 30 m and 5 m • Steel/ wooden pegs • String • Bush knives • Grass cutter • Hoe • Baskets • Axes • Shovels • Wheel barrows	Material:
Quality Control: Before activity is carried out: • Is setting out done correctly? • Are pegs and string line placed correctly? While activity is carried out: • Make sure the deposited material is placed far enough from the road formation. • Make sure the cleared width is free of roots, tree branches, grass etc. and big rocks. Final check: • Final check of above listed activities.		

	WORK SHEET
Filling sub-Base selected class C material (or natural gravel)	WS-02
Specification: The activity comprises provision of suitable sub base materials on site from selected materials, and the spreading and compaction of these materials on the compacted sub grade layer. Materials selected for use as sub base shall be aggregate/gravel with proper grading proportions, meeting the requirements in the class C material specification. It shall be free of lumps of organic or other detrious materials.	
Work Method: • Set out road level and camber of 4% cross fall using pegs and strings. Pegs are to be set at road centre line and road edges with 10 m distance intervals between the pegs. Mark designated level on the pegs and tie the string line. • Sub base materials shall be placed and spread by workers by using proper hand tools (hoe, baskets, wheel barrow and spreader) up to the set level. • Provide compaction of 8-10 passes by 6-8 ton vibrating steel wheel roller. Compaction shall be done layer by layer, parallel to the road centre line, and from edges of the road towards the road centre line. Each compaction layer must not exceed 15 cm in thickness. Full compaction has to be achieved with appropriate equipment and optimum moisture content as required by the specification. Watering shall be applied during the gravel spreading activity, ensuring that the gravel is uniformly moisted. The number of passes of compaction has to be determined through tests. Usually 6 to 8 passes are sufficient if the moisture content is optimal.	  

Manpower: • 1 Supervisor(part time) • 2 part time workers for setting out set pegs and string line • 1 Work gang spreading and hauling the delivered gravel	Tools + Equipment: • Tape Measures, 30 m and 5 m • String line & Hammer • Wooden/ steel Pegs & Strings • Spreader • Baskets • Wheel barrow • Steel wheel roller 6-8 tons • Water tanker • Camber board	Material: • Selected material class C
Quality Control: Before activity is carried out: • Is setting out done correctly? • Are pegs and string line placed correctly? • Is camber board used? While activity is carried out: • Make sure width is cleared before the activity is started, and ensure that the area is free of trees, bushes, shrubs, grass and roots before filling & compaction. • Make sure compaction is uniform by counting number of passes, and by moving over the surface in a decided pattern. Also ensure that there is always a lateral overlap of at least 20 cm from pass to pass. • Make sure thickness of each layer is sufficient. Final check: • Make sure the road surface is even, and that no soft spots are left after compaction. • Make sure road longitudinal level (from one edge to edge) is conform and with proper camber. • If basic laboratory equipment is available CBR test and Sieve analyze should be made.		
Suggested Productivity: Spreading and hauling of delivered gravel 5-7 m ³ /Wd		

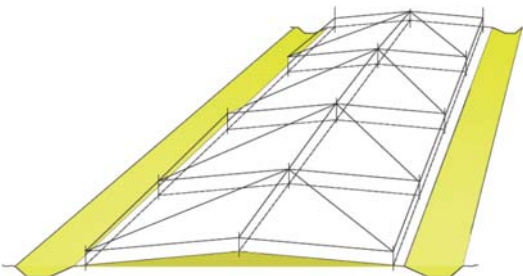
	WORK SHEET
Telford base	WS-03
Specification: Telford base is used when there is need for shifting out road section material where sub grade is weak. The work consists of placing stone curbs, spreading sand base material, and placing stones of different sizes in vertical position to form a even and strong pattern. The Telford base structure shall be put before filling road base course.	
Work Method: - Set out road level and camber of 4% cross fall using pegs and strings. Pegs are to be set at road centre line and road edges with 10 m distance intervals between the pegs. Mark designated level on the pegs and ties the string line. - Set out curb line on both road edges using pegs and strings.	
- Place curb stones in vertical position along the road edge lines on both sides of the road. Ideal size of stones for curb are 15-25 cm - Spread the sand base layer of about 10 cm thickness between the curb lines.	
- Place the stones in vertical position direct on the sand. The stones shall be placed from edge of the road towards the road centre. The stone size shall be 10-15 cm. - When the bigger stones are put in place, fill smaller 5-7 cm stones in the gaps between the big stones. Finally put 2-3 cm aggregate on top of the stone layer. - It is important that the filled smaller stones are placed as dense as possible to ensure minimal movement of the structure after filling. - Provide compaction with a 6-8 ton vibrating steel wheel roller or equivalent after completion of stone placement & filling	

		
Manpower: • 1 Supervisor (part time) • 2 workers (part time for setting out, putting pegs & string) • 1-2 workers to spread sand • 1 Work gang to place the stones	Tools + Equipment: • Pegs and string • Hoe • Shovels • Spreader • Tape measures, 30 m and 5 m • Baskets • Hammers • Roller • Camber board	Material: • Sand • Stone 15-25cm • Stone 10-15cm • Stone 5-7cm • Aggregate 3-5 cm
Quality Control: Before activity is carried out: • Is setting out done correctly? • Are pegs and string line placed correctly? • Is camber board used? While activity is carried out: • Make sure selected stones are of good and durable quality. • Make sure the stones are placed in vertical position, and that the stone quantity is based on this prerequisite. • Make sure the filling stones are as densely put as possible to ensure minimum movement of the structure after completion. Final check: • Make sure the finishing level of the Telford base structure is even. • Make sure road longitudinal level (from one edge to edge) is conform and with proper camber.		

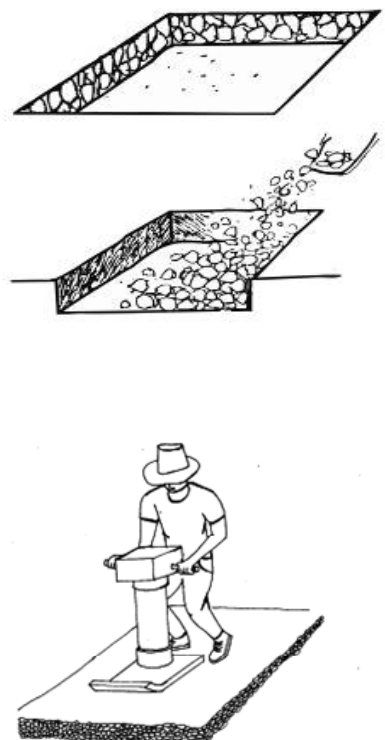
	WORK SHEET
Road base course with different stone sizes (Macadam)	WS-04
Specification: The activity comprises provision of selected material and placing and compaction of the selected material on the sub base or Telford base layer. Materials selected for use as base course shall be difference size of stone with correct properties referring to grading and strength according to material specification. The selected material shall be free of lumps of clay, organic or other deterious materials, and shall have such a quality that a stable road surface can be obtained.	
Work Method: - Set out road level and camber of 4% cross fall using pegs and strings. Pegs are to be set at road centre line and road edges with 10 m distance intervals between the pegs. Mark designated level on the pegs and ties the string line. - Fill base course material starting with the largest fraction. Material of 7-5 cm crushed stone shall be placed at the bottom and inter lock with smaller size crushed aggregates 5-3 cm and 3-2 cm. The base course materials shall be placed up to designed level. - Provide compaction of 8-10 passes by 6-8 ton vibrating steel wheel roller. Compaction shall be done layer by layer, parallel to the road centre line, and from edges of the road towards the road centre line. Each compaction layer must not exceed 15 cm in thickness. Full compaction has to be achieved with appropriate equipment and optimum moisture content as required by the specification. Watering shall be applied during the gravel spreading activity, ensuring that the gravel is uniformly moisted. The number of passes of compaction has to be determined through tests. Usually 6 to 8 passes are sufficient if the moisture content is optimal.	  



Manpower: • 1 Supervisor (part time) • 2 part time workers for setting out set pegs and tie string. • 1 Work gang spreading & hauling the delivered gravel	Tools + Equipment: • Tape Measures, 30 m and 5m • String line & Hammer • Wooden/ steel Pegs & Strings • Spreader • Baskets • Wheel barrow • Steel wheel roller 6-8 ton • Camber board	Material: • Selected material difference size of crushed aggregate • Maximum size shall not be bigger than 7 cm
Quality Control: Before activity is carried out: • Is setting out done correctly? • Are pegs and string line placed correctly? • Is camber board used? While activity is carried out: • Make sure width is cleared before the activity is started, and ensure that the area is free of trees, bushes, shrubs, grass and roots before filling & compaction. • Make sure compaction is uniform by counting number of passes, and by moving over the surface in a decided pattern. Also ensure that there is always a lateral overlap of at least 20 cm from pass to pass. • Make sure thickness of each layer is sufficient. Final check: • Make sure the road surface is even, and that no soft spots are left after compaction. • Make sure road longitudinal level (from one edge to edge) is conform and with proper camber. • If basic laboratory equipment is available CBR test and Sieve analyze should be made.		
Suggested Productivity: Spreading of delivered gravel 5-7 m ³ / Wd		

		WORK SHEET
Base course with selected class A material (crushed aggregate mixed with aggregate dust)		WS-05
Specification: The activity comprises provision of selected class A material, and spreading and compaction of the selected material on the compacted sub base. Materials selected for use as class A base course shall be crushed stone/aggregate with correct properties referring to grading and strength according to material specification, and shall be free of lumps of organic or other deterious materials.		
Work Method: - Set out road level and camber of 4% cross fall using pegs and strings. Pegs are to be set at road centre line and road edges with 10 m distance intervals between the pegs. Mark designated level on the pegs and ties the string line. - Base course selected class A materials shall be placed and spread by workers with proper hand tools (hoe, baskets, wheel barrow and spreader) up to the set level. - Provide compaction of 8-10 passes by 6-8 ton vibrating steel wheel roller.. Compaction shall be done layer by layer, parallel to the road centre line, and from edges of the road towards the road centre line. Each compaction layer must not exceed 15 cm in thickness. Full compaction has to be achieved with appropriate equipment and optimum moisture content as required by the specification. Watering shall be applied during the base course class A spreading activity, ensuring that the gravel is uniformly moisted. The number of passes of compaction has to be determined through tests. Usually 6 to 8 passes are sufficient if the moisture content is optimal.		  
Manpower: 1 Supervisor(part time) 2 part time workers for setting out set pegs and string line	Tools + Equipment: - Tape Measures, 30 m and 5 m - String line & Hammer	Material: Selected material class A

• 1 Work gang spreading and hauling the delivered gravel	• Wooden/ steel Pegs & Strings • Spreader • Baskets • Wheel barrow • Steel wheel roller 6-8 ton • Camber board	
Quality Control: Before activity is carried out: • Is setting out done correctly? • Are pegs and string line placed correctly? • Is camber board used? While activity is carried out: • Make sure width is cleared before the activity is started, and ensure that the area is free of trees, bushes, shrubs, grass and roots before filling & compaction. • Make sure compaction is uniform by counting number of passes, and by moving over the surface in a decided pattern. Also ensure that there is always a lateral overlap of at least 20 cm from pass to pass. • Make sure thickness of each layer is sufficient. Final check: • Make sure the road surface is even, and that no soft spots are left after compaction. • Make sure road longitudinal level (from one edge to edge) is conform and with proper camber. • If basic laboratory equipment is available CBR test and Sieve analyze should be made.		
Suggested Productivity: Spreading and hauling of delivered gravel 5-7 m ³ / Wd		

		WORK SHEET
Pothole patching		WS-06
Specification: Potholes in a road section are results of a road structure in bad shape. The pothole appears when the bearing loading capacity of sub grade layers decrease for various reasons, making the pavement sink in the particular spot and consequently break from stress. The activity consists of repairing and patching of potholes (= failed areas requiring excavation and reconstruction of pavement and/ or sub grade layers), using the same or equivalent materials as in the surrounding layers being patched unless otherwise directed by the contract Supervisor. The surface material of the repaired pothole must be the same material as described in the specification for the actual road section.		
Work Method: - The Engineer shall decide which potholes to repair and mark them. - The pothole shall be cut into rectangular shapes. The width and depth of excavation depends on the extent of failed materials, and space needed for compaction. Remove the failed material including surrounding affected parts of pavement. - Fill selected material (sub base and/ or base course, and pavement). The material to be filled in the pothole shall be same material as used in the surrounding areas to ensure strength and durability. - The thickness of each layer shall not be more than 10 cm. Filling and compacting operations shall commence from the lowest layer. Filling and compaction shall be done in accordance with the relevant specification for the material. - After completion of the patch with the top layer, mechanical compactor shall be used to compact the top layer according to specification.		
Manpower: 1 Supervisor (part time) - Workers for cutting and trimming the pothole - worker for filling the selected material - Workers for re-surfacing	Tools + Equipment: - Bitumen sprayer - Local product spraying bucket - Bitumen carrying buckets - Pick axe and hoes - Machine for cutting the asphalt - Pedestrian roller and mechanical temper	Material: - Selected sub base and base course materials - Bitumen - Difference size of crushed aggregate - Selected sand

Quality Control:

Before activity is carried out:

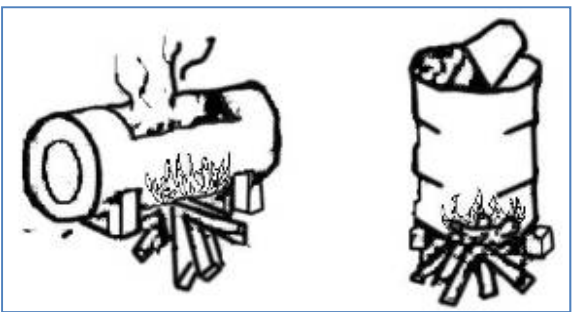
- Make sure all identified potholes are marked.

While activity is carried out:

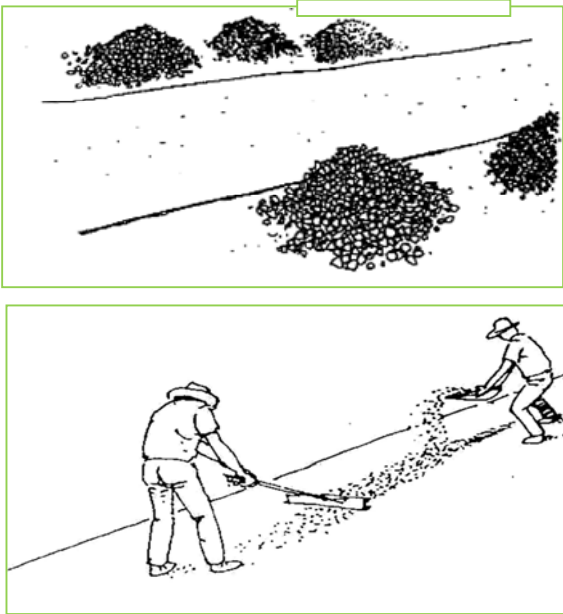
- Make sure the pavement around the pothole is cut in rectangular shape.
- Make sure that the failed material is replaced.
- Make sure each layer is properly compacted.
- Make sure pothole is dry before adding new material.

Final check:

- Make sure all failed materials are replaced and removed from the road section.

		WORK SHEET
Prime Coat		WS-07
Specification: When a bituminous surfacing material is to be applied to an untreated road surface, it is of great importance that the untreated surface is dry, clean and as dust free as possible. Priming helps to improve adhesion between the road base and bituminous surfacing. It also seals surface pores in the road base. The work consists of the preparation of the base layer, and the application of prime coat.		
Work Method: • Brush the compacted base course surface using broom or steel brush, or alternatively by using an air compressor. • Heat bitumen to required temperature as mentioned in material specification. Temperature may vary between different types of bitumen. The bitumen shall then be mixed with kerosene in proportion 35-40% of total volume. • The cleared surface shall be approved by the contract supervisor and shall be sprayed lightly with water before application of the prime coat. • Spray the heated bitumen mix to the cleaned road base using bitumen sprayer. The bitumen mix spray rate shall be 0.8-1.4 litres/m². The application amount of bitumen depends on the density of the road base course and special instructions given by the contract supervisor. • The prime surface shall not be subject to traffic over a minimum time period of 8 hours.		  
Manpower: • 1 Supervisor (part time) • 1 Worker heating and maintaining	Tools + Equipment: • Steel brush, broom, air compressor	Material: • Bitumen • Kerosene

- temperature of bitumen • 1 worker spraying bitumen • Workers carrying bitumen	• Bitumen sprayer or (if not available) local product spraying bucket • Toe tractor or toe truck • Bitumen carrying buckets • Bitumen thermometer	• Fire wood
Quality Control: Before activity is carried out: • Is setting out done correctly? • Make sure the road base is clean and well compacted. While activity is carried out: • Make sure the prime coat mix has the correct proper proportions of kerosene and bitumen. • Make sure the temperature of the heated bitumen is as stated in the material specification. • Make sure the bitumen application spray rate is sufficient; i.e. measure bitumen use and divide with road area covered. Final check: • Make sure prime coat has properly covered desired area.		

	WORK SHEET
Penetration Macadam Pavement	WS-08
Specification: The penetration macadam pavement is commonly used as surface layer on roads in Indonesia. The work consists of providing bitumen stabilized aggregate over a new or repaired base course. The penetration macadam surface constitutes a consolidated layer thickness of 50 mm, obtained by two or three application of hot bitumen, alternated with three applications of aggregates.	
Work Method: • Set out road level and camber of 4% cross fall using pegs and strings. Pegs are to be set at road centre line and road edges with 10 m distance intervals between the pegs. Mark designated level on the pegs and ties the string line. • The different fractions of crushed aggregate to be used for the penetration macadam surface shall be placed along the road in orderly arranged heaps. • After spraying the prime coat, apply the first layer of crushed aggregate in sizes 3-5 cm, inter locked with aggregate in sizes 2-3 cm at an amount rate of about 80-100 kg/m². Apply compaction immediately using an 8-10 ton steel wheel roller for a minimum of 10 passes at a speed of not more than 5 km/h.	
• Spray heated bitumen on the compacted coarse aggregates. Application rate shall be a minimum of 4.5 litres/m², applied as uniformly as possible at the temperature stated in the specification.	

While the first application of bituminous material is still warm and plastic, the second layer of aggregate in sizes 1-2 cm shall be spread at a rate of about 25 kg/m² Apply compaction immediately using a 8-10 ton steel wheel roller for a minimum of 10 passes at a speed of not more than 5 km/h.		
- The next applied layer of bitumen is to be sprayed at a minimum rate of 1.5 litres/m² is sprayed on top of the previous compacted aggregate layer at temperatures stated in the material specification. - While the bituminous material is still warm and sticky, the third layer of fine aggregate or coat sand in sizes 0-0.5mm (or aggregate chippings) shall be spread at an amount rate of about 8-10 kg/m². Apply compaction immediately using a 8-10 ton steel wheel roller for a minimum of 10 passes at a speed of not more than 5 km/h. The last passes shall make sure the final surface is smooth and even.		
Manpower: 1 Supervisor (part time) 1 Worker heating and maintaining temperature of bitumen - Skilled worker(s) spraying bitumen 1 Work gang carrying bitumen 1 Work gang spreading aggregate	Tools + Equipment: - Bitumen sprayer or (if not available) local product spraying bucket - Measuring bucket for measuring hot bitumen - Measuring tapes 30 m and 5 m - Baskets - String line and pegs - Spreader - Shovel - Roller - Bitumen thermometer	Material: - Crushed aggregate: -size:3-5 cm -size 2-3 cm -size 1-2 cm -size 0-0.5cm or coat sand - Bitumen - Fire wood Remarks: all material shall be applied to specification
Quality Control:		

Before activity is carried out:

- Is setting out done correctly?
- Are pegs and string line placed correctly?
- Is camber board used?
- Make sure aggregate of correct properties is used, and that aggregate/coat sand is free from dust, dirt and clay.
- Make sure to use of correct type of bitumen is used of correct proportions.

While activity is carried out:

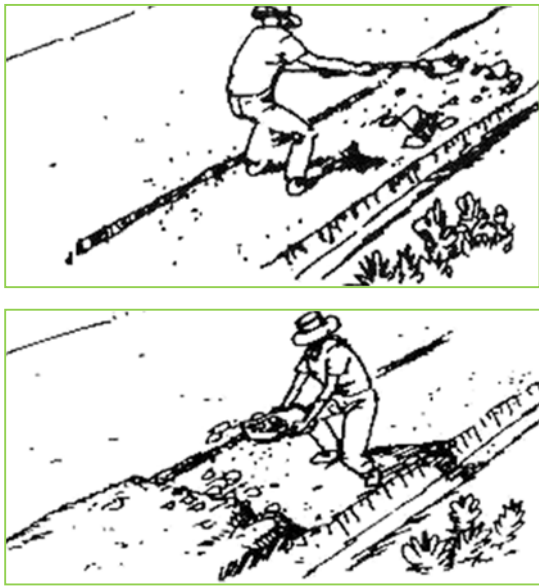
- Make sure all heated bitumen is used not more than 1 day.
- Make sure the bitumen is heated at correct temperature due to specification.
- Make sure the heated bitumen sprayed as uniformly as possible.
- Make sure to spread crushed aggregate uniformly, and that the correct size of aggregate and thickness of each layer is controlled..
- Make sure that compaction activities are assumed as soon as material has been spread.
- Make sure all three layers are completed within a maximum of 2 to 3 days.

Final check:

- Make sure the road surface is even after compaction.
- Make sure the total surface is covered by the last layer material (sand).

		WORK SHEET
Sand Seal Pavement		WS-09
Specification: The sand seal surface dressing is intended for strengthening an existing bituminous surface in good condition. The work consists of constructing a one layer road paving, consisting of a bituminous binder covered with aggregate chippings/ grade sand.		
Work Method: - Set out pegs and strings at both edges of the road in 10 m intervals. - Clean and broom/ brush the surface properly clearing away all dirt and foreign materials. - Apply the bitumen at an amount rate of 1.5 liter/ m² at specified temperature.		
- Apply cover aggregate/ selected sand to the binder immediately. - Compact the treated surface using steel wheel roller. - Sweep loose aggregates/selected sand into the wheel paths after 48 hours.		 
Manpower: 1 Supervisor (part time) 1 Worker heating and maintaining	Tools + Equipment: Bitumen sprayer or (if not available) local product spraying	Material: Cover Aggregate size: 0-0.5 cm or

- temperature of bitumen • Skilled worker(s) spraying bitumen • 1 Work gang carrying bitumen • 1 Work gang spreading aggregate/coat sand	- bucket • Measuring bucket for measuring hot bitumen • Measuring tapes 30 m and 5 m • Baskets • String line and pegs • Spreader • Shovel • Roller • Bitumen thermometer	- coat sand. • Bitumen • Fire wood Remarks: all material shall be applied to specification
Quality Control: Before activity is carried out: • Is setting out done correctly? • Are pegs and string line placed correctly? • Is camber board used? • Make sure sand of correct properties& course is used, and that aggregate/ coat sand is free from dust, dirt and clay. • Make sure to use the correct type of bitumen While activity is carried out: • Make sure all heated bitumen is used not more than 1 day. • Make sure the bitumen is heated at correct temperature due to specification. • Make sure the heated bitumen sprayed as uniformly as possible. • Make sure sand is spread uniformly. • Make sure that compaction activities are assumed as soon as material has been spread. Final check: • Make sure road surface is even after compaction. • Make sure the total surface is covered by the last layer material (sand).		

	WORK SHEET
Road shoulder repair	WS-10
Specification: The road shoulders are located outside the pavement edge on both sides of the road. Their function is to support the pavement edge, and to even the difference in level between the road surface and the slope crest. The work consists of preparing, placing and compacting shoulder material on a prepared sub grade or other approved area where new or improved shoulder construction is required in accordance with drawings or as instructed by contract supervisor. The material to be used for the work shall be approved by the contract supervisor. The top width of the shoulder shall be from 0.5 m to 1.0 m.	
Work Method: • Road shoulder work should be done immediately after completion of paving work. • Set out and pegs at edge of road and edge of shoulder. Set level of cross fall minimum 4% start from outer edge of the road. Tie string along the road in 10 m intervals. • Fill and spread selected material. The material for shoulder repairing shall be appropriate for back filling purpose, such as mountain gravel, (laterite), selected class C material or other suitable selected material approved by the supervisor. The selected material must not contain any organic material, such as roots and tree branches, or any other plant debris or garbage. The material shall be spread in layers of maximum 150 mm and compacted layer by layer using a small vibratory compactor until maximum density is reached.	
• Compaction shall be carried out from the outer edge of the shoulder towards road edge. Water shall be applied in order to optimize the material moisture content for best compaction result. The finishing layer shall be compacted until the surface is even . • The minimum cross fall of 4 % shall be observed when the finishing layer of the road shoulder is put into place. • Elevation of the repaired or constructed shoulder must not be higher than the pavement edge.	

Remarks: For road shoulders to be filled higher than 20cm, benching should be applied, not higher than 15 cm on each step. Fill the cut area and apply compaction. Continue procedure to designed level.		
Manpower: • 1 Supervisor (part time) • Workers carrying bitumen • Workers spreading the selected material • Workers excavating selected soil	Tools + Equipment: • Measuring tapes 30 m and 5 m • Baskets • String line and pegs • Spreader • Shovel • Hoe • Vibrating compactor	Material: • Selected soil at the bottom layer • Selected class C material or mountain gravel
Quality Control: Before activity is carried out: • Is setting out done correctly? • Are pegs and string line placed correctly? • Is camber board used? While activity is carried out: • Make sure that soil in the bottom layer is free from organic material and tree roots. • Make sure compaction is carried out at optimum moisture content, and that each layer is not more than 15 cm thick. • Make sure the material to be used in the last layer is selected class C material or mountain gravel. • Make sure the finishing level is the similar or same level as the pavement edge level. Final check: • Make sure road surface is even after compaction. • Make sure sufficient width of shoulder.		
Suggested Productivity range: 1.5 to 2 m ³ / wd		

	WORK SHEET
Filling base course (use steel shutter system)	WS-11
Specification: The activity comprises provision of selected base course material class “A”, spreading, watering and compaction of the selected material on a compacted sub base. Materials selected for use as class “A” base course shall be crushed stone/aggregate with correct properties referring to grading and strength according to material specification, and shall be free of lumps of organic or other deteriorous materials. Steel shutter to be used as formwork for gravel spreading activity.	
Work Method: - Erect steel shutter (L- sharp steel of 10cm x 10 cm) and steel bulking rail (extended on top of the steel shutters prefer 4 cm height = loose thickness of the base) at road edges and centre line. The steel shutter shall be erected at centre line and at both road edges. Level of steel shutter at the centre line shall be 4% higher than the edges meaning camber of the road is 4%. Use line level to transfer shutter level and set the camber of the road. The steel shutter at the edges should be extended 20 cm outside the road edges. The steel shutter shall be fixed to the road base with steel pegs for every 1.5-2.0 m - Deliver selected base course materials along the road. The engineer should inspect approve quality of material before delivering. Laboratory testing (sieve analysis and CBR) of the material is needed. Distance from one heap to other of material to be delivered should be calculated based on designed base thickness and width of the base and quantity of material of each truck. Ex: - 1 truck= 4 m³ of gravel => carriage way width=3 m; base width 3.4 m => compacted thickness= 10 cm or loose thickness =14 cm $\text{distance between heaps} = \frac{4 \text{ m}^3}{3.4 \times 0.14} = 8.4 \text{ m}$ - Spread the gravel to top level of the bulking rails by labours with proper hand tools like: spreaders, shovels, wheel barrows, hoes and baskets. Screeding is needed after spreading of the material.	

- Apply water uniformly to get optimum moisture content. Compaction for 2-3 passes without vibration after watering and continue for final compaction of another 8-10 passes with vibration mode. Compaction shall be done parallel to the road centre line, and from edges of the road towards the road centre line.
- Full compaction has to be achieved with appropriate equipment and optimum moisture content as required by the specification. Water shall be applied during or immediately after spreading activity, ensuring that the gravel is uniformly moistened. The number of passes of compaction has to be determined through tests. Usually 8 to 10 passes with 3-6 tons roller are sufficient if the moisture content is optimal.
- Steel shutters and bulking rails should be removed after final compaction of the base. The shutters and bulking rails can then be erected for other road section extending from the completed base course section.
- Fill shoulder material immediately after removal of the shutters and bulking rails and follow with watering and compaction



Manpower:

- 1 supervisor(part time)
- 2 part time workers for setting out and erect shutters and bulking rail.
- 1 work gang spreading and hauling the gravel
- 1 part time worker watering the base after or during spreading
- 1 roller operator.

Tools + Equipment:

- tape Measures: 30 m and 5 m
- steel shutters(L-steel 10cm x 10 cm), bulking rails(steel 40mm) and steel pegs
- screeding steel box 50 mm x 100 mm
- hammer
- spreaders, shovels
- baskets
- wheel barrows
- vibrating roller

Material:

- selected base course material class "A"

	• line level and fishing line • water pump and water bowser	
Quality Control:		
Before activity is carried out:	• Is setting out done correctly? Are the steel shutters and bulking rails erected properly? • Make sure spacing between the erected shutters and bulking rails are correct • Make sure level of the erected shutter at center line and at the road edges has cross fall 4% • Make sure selected material has been tested. If basic laboratory equipment is available CBR test and Sieve analyze should be made. • Are hand tools in good condition? • Make sure road width is cleared before the activity is started, and ensure that the area is free of trees, bushes, shrubs, grass and roots before filling & compaction.	
While activity is carried out:	• Make sure the gravel has been spread to top level of the bulking rails in all areas • Make sure watering uniformly in all areas and achieve moisture contain before compaction is started • Make sure compaction is uniform by counting number of passes, and by moving over the surface in a decided pattern. Also ensure that there is always a lateral overlap of at least 20 cm from pass to pass. • Make sure where segregation of aggregate shall be rectified by fine material before compaction has been started	
Final check:	• Make sure the road surface is even, and that no soft spots are left after compaction. • Make sure road longitudinal level (from one edge to edge) is conform and with proper camber. • Make sure all shutters and bulking rails have been removed and continuing use to other road sections • If basic laboratory equipment is available, DCP and density tests should be made after final compaction. Compaction density shall be applied minimum. 98% of Mod AASHTO • Make sure exceeded material from the base has been hauled and reused to other uncompleted sections	
Suggested Productivity: Spreading and hauling of delivered gravel 5-7 m ³ / Wd		

	WORK SHEET
Prime coat using bituminous emulsion	WS-12
Specification: The work comprises of preparation of base layer, and application of bituminous emulsion prime coat. When a bituminous surfacing material is to be applied to an untreated road surface, it is of great importance that untreated surface is dry, clean and as dust free as possible. Priming helps to improve adhesion between the road base and bituminous surfacing. It also seals surface pores in the road base.	
Work Method: • <u>Preparation of base:</u> remove dust and loose material from compacted road base using air compressor or alternatively using brooms. The sweeping shall be done carefully not to damage road base and no longer than 24 hrs before applying bituminous emulsion. • The cleared surface shall be approved by the contract supervisor and apply light spray water to base uniformly immediately before application of bituminous emulsion prime. • Setting steel guide rails(steel box 20mm x 20 mm) or rope at both side road edges. The guide rails or ropes should be set allow 10cm outside road edges. Placing plastic sheet or reinforce paper at starting and finish points of spraying. Lightly placing sand outside the guide rails to make sure primer stays on the inside. • <u>Prime coat application:</u> bituminous emulsion for the priming should be CSS-60 1s. Temperature of the emulsion shall be 45-60 °C, if the temperature of the emulsion less than 45, heating emulsion is needed before application of the prime. Using metal sheet protective screens to keep spraying within road area and to keep neat road edges. Two assistance holding protective screens. The protective screens shall be placed and roll over the guide rails along the road edges. Shaking emulsion before starting application of the prime. • While spraying the tack coat, two persons should assist the spraying operator to move the motorized sprayer. The spraying shall be carried out backward in a speed depend on application rate. • Applying prime evenly with motorized hand sprayer with application rate 0.6-0.7 litres/m². The application rate of emulsion depends on the density of the road	

base course and special instructions which are given by engineer or contract supervisor. The spraying emulsion alternatively can be done using broom in the absence of hand sprayer. • Protect all road furniture with suitable protective material when spraying emulsion. • <u>Cleaning equipment:</u> after spraying prime coat, the hand sprayer shall be cleaned following steps bellow: ○ pour kerosene in a 20 litre container (or bucket) ○ place the suction end of pump into the 20 litre container and nozzle of the sprayer into another empty bucket ○ start engine of the sprayer and allow the kerosene to run through the and sprayer system until clean. <u>Note:</u> a) The prime shall not applied: ○ to surface layer in wet condition ○ when rain is imminent ○ when temperature of surface below 10 °C ○ after sunset b) the bituminous emulsion shall be shaken for every 2-3 days to maintain quality of the emulsion			
Manpower: • 1 supervisor (part time) • 1 air compressor operator • 1 emulsion hand spraying operator and 2 helpers • 2 helpers holding protective screens • 1 setting out worker (part time)	Tools + Equipment: • Tape Measures, 30 m and 5m • Steel guide rails (hollow steel box 20mm x 20 mm) and nails or rope • 2 Metal protective screens • Hammers • Hand brooms • Air compressor • Motorized hand sprayer • Water hose • Buckets • Wheel borrows	Material: • Emulsion bitumen: CSS-60- 60% 1 s • Kerosene • Reinforced paper or plastic sheet	
Quality Control: Before activity is carried out: • Check if the equipment: air compressor and emulsion hand sprayer are functioning • Make sure guide rails are in placed correctly. • Make sure the road base is clean and well compacted. • Make sure the road base is dry before starting sweep the base			

While activity is carried out:

- Make sure road base is cleaned before applying emulsion.
- Make sure the temperature of the emulsion is in rank 45-60 °C
- Make sure the bitumen application spray rate is sufficient; i.e. measure emulsion drum before and after using. amount of the emulsion divide with road area covered.
- Make sure the bitumen application spray as uniform as possible

Final check:

- Make sure prime coat has properly covered desired area.
- Make sure all equipment are cleaned after priming

Suggested Productivity: 2,100 m²/ team ; Team consist of 6 peoples

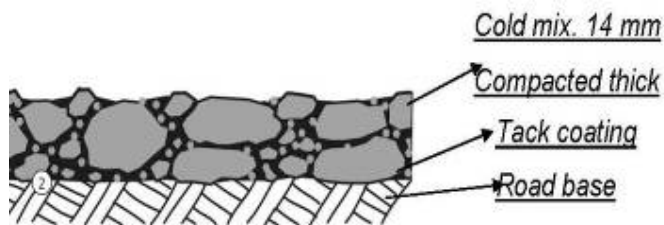
	WORK SHEET
Cold mix asphalt (manual mixing of asphalt)	WS-13
Specification: Cold mix asphalt seal is a premix seal of bituminous emulsion and continuous sizes of graded aggregates. The work comprises mixing of the cold mix, hauling and placing the asphalt, spreading on a bituminous emulsion tack coat at the predetermined application rate and compaction. The mixing of the asphalt in accordance to mixing proportion determined by engineer and specified in the specification. The aggregates shall be free of dust and organic material. Mixing of the asphalt cold mix can be done by concrete mixer or in situ manually. This work sheet is demonstrating mixing of the asphalt cold mix manually.	
Work Method - Placing guide rails (20mm x 20mm steel box sections) along road edges and road centre line and quarter points of the road. Check accuracy level of the guide rails, where lower than 20mm it should be adjusted with extra asphalt or piece of aggregate to achieve same level. - Apply tack coat using bituminous emulsion of 60% CSS 1 s. The emulsion shall be diluted with water at the ration of 1:1. Use a watering can and broom for tack coating between the guide rails. Application rate of the tack coat should be 0.6-0.7 litre/m2. <u>Placing mixing pens and aggregates:</u> - the mixing pens should be placed in situ where spacing from one to other should be calculated based on required volume of asphalt to be placed. The mixing pens are moved continuously forward after discharging the mixed asphalt. Aggregate for the mixing can be deposited on a completed road section nearest to the road section to be sealed. <u>Mixing the cold mix asphalt:</u> - Use measuring cans and add correct predetermined amount of aggregate to the mixing pens. Size of the aggregate shall be applied as per grading envelope and approved by engineer before added to the mixing pen. Apply water lightly of amount 1% of mass of aggregate and mix thoroughly.	

- Pour bituminous emulsion of 65% CMS 2h (company code: E-71) on the heap of wet aggregate in the pens of correct pre determined amount. Usually, the proportion of bituminous emulsion should be 8.5-9.5% of the mass of the asphalt
- Start mixing manually immediately by using proper hand tools like spreader or hoes and shovels. The mixing shall be done continuously until all part of the mix are covered by bitumen.
- Immediate after the mixing, the mixed asphalt shall be discharged directly from the pens onto tack coat base at middle point between the two guide rails.
- After discharging the asphalt from the mixing pens, the mixing pens will then be moved to other unsealed sections and continue sequence of the mixing process.
- Spreading shall be commenced immediately after the asphalt from the mixing pens has been discharged. The spreading commences from heap of the asphalt toward guide rails. Ensuring the spreading level of the asphalt same as level of the guide rails. Area of adjacent to the guide rails to be filled by asphalt. Screeding will follow the spreading to ensure level of the spread asphalt is as smooth as possible.
- Once the screeding has been completed, the guide rails shall be removed to allow compaction. Roller can then commence with low speed of less than 5 km per hours using a 3-5 tons roller. Wet wheels of the roller before commencing the compaction to avoid asphalt sticking to the wheels. Compaction should be done for 6-8 passes. It is recommended that, rolling of first 2 passes should be done in static mode. Vibrating mode can started from the 3rd pass until finish



Cleaning the equipment:

- All hand tools used for spreading the asphalt should be continuously cleaned using kerosene.
- The mixing pens shall be cleaned for every 2-3 mix to avoid asphalt sticking in the pens. The pens can be cleaned using a shovel to remove the remained asphalt.



Manpower:

- 1 supervisor (part time)
- 1 tack coating worker (part time)
- 1 part time worker for setting out guide rails.
- 1 work gang for hauling crushed aggregate and measure for mixing (size of the gang depend on demand progress of work)
- 1-2 workers for each mixing pens
- 1 work gang for spreading and screeding asphalt (size of the gang depend on demand progress of work)
- 1 roller operator.

Tools + Equipment:

- Tape Measures, 30 m and 5m
- Guide rails (steel hollow box 20mm x 20mm)
- Hammers
- Nails
- Hand broom
- Spreaders
- Buckets
- Wheel barrows
- Roller.
- Shovels
- Mixing pens
- steel box (steel hollow box 30mmx30mm) for screeding
- Measuring cans

Material:

- Bituminous Emulsion bituminous for tack coat 60% CSS 1 s
- Bituminous for asphalt 65% CMS 2 h (company code E-71)
- Kerosene
- Crushed Aggregates

Quality Control:

Before activity is carried out:

- Check if the equipment: mixing pens and hand tools are in good condition
- Make sure guide rails are in placed correctly.
- Make sure aggregates are cleaned.

While activity is carried out:

- Make sure to use the correct type of bituminous emulsion.
- Make sure the temperature of the emulsion is in rank 45-60 °C
- Make sure mixing proportion(water, emulsion, aggregate) are correct and the mixing is proper done.
- Make sure to spread asphalt to level of guide rails and no waving on the completion surface. In any places where appearing low spots, asphalt shall be used for filling the spots before commencing compaction.
- Make sure that compaction activities are assumed as soon as material has been spread and control passes of the rolling.
- Make sure compaction is uniform regarding rolling pattern and number of passes. Also ensure that there is always a lateral overlap of at least 20 cm from pass to pass

Final check:

- Make sure road surface is even and well compacted.
- Make sure all tools and equipment have been cleaned after using
- Make sure all guide rails have been removed and continuing use to other road sections
- Make sure exceeded material(aggregate and sand) have been hauled and reused to other uncompleted sections
- Make sure remaining asphalt on completed sections or road section to be sealed are cleaned.

	WORK SHEET
Cold mix asphalt (using concrete mixer)	WS-14
Specification: Cold mix asphalt seal is a premix seal of bituminous emulsion and continue size of graded aggregate. The work comprises mixing of the cold mix, hauling and placing the asphalt, spreading on a bituminous emulsion tack coat at the predetermined application rate and compaction. The mixing of the asphalt in accordance to mixing proportion determined by engineer and specified in the specification. The aggregated shall be free of dust and organic material. Mixing of the asphalt cold mix can be done by concrete mixer or in situ manually. This work sheet is demonstrated mixing of the asphalt using a concrete mixer.	
Work Method: - Placing guide rails(20mm x 20mm steel box sections) along road edges and road centre line and quarter points of the road. Check accuracy level of the guide rails, where lower than 20mm should accommodate with extra asphalt or piece of aggregate to achieve same level. - Apply tack coat using bituminous emulsion of 60% CSS 1 s. The emulsion shall be diluted with water of a composition 1:1. Use watering can and broom for tack coating between the guide rails. Application rate of the tack coat should be 0.6-0.7 litre/m². <u>Placing mixture and aggregate:</u> - Area for the concrete mixer stand should be at shoulder where more space available. The mixer should be as close as possible to the pouring to avoid longer hauling of the asphalt has been mixed. Aggregate for the mix should be deposited close to the mixer. Use buckets for measuring aggregate prior mixing <u>Mixing the cold mix asphalt:</u> - Use measuring cans add correct amount of aggregate to the mixer while the mixing drum is operating. Proportion of the mix shall be determined by engineer or as specified in the technical specification. Water is then added slowly to the drum and mixing continued until the aggregate is thoroughly dampened. Amount of the water should be 1% of mass of the aggregate. - Add bituminous emulsion 65% CMS 2 h (company code: E-71) slowly pour into the drum continuously	

while the mixer is operating. Continue operating the mixture until the all parts of aggregates are covered by the bitumen. The mixer should be operated as slowly as possible. The drum should be tilted so that the position is in between vertical and horizontal. Composition of the aggregate and emulsion shall be predetermined by the engineer or specified in the technical specification. Usually, the proportion of bituminous emulsion should be 8.5-9.5% of the mass of the asphalt

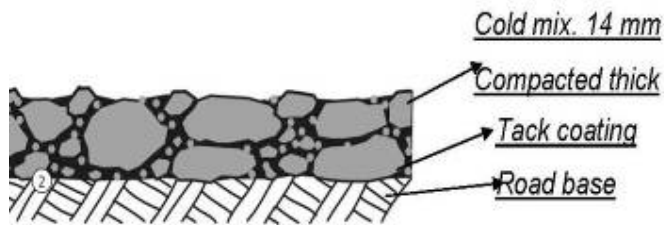
Note: Aggregate should not be filled more than 1/3 of the volume of the mixer drum.

- Immediate after the mixing, the asphalt should be discharged to wheel barrows and hauled to a prepared base(tack coated) ready for spreading. Wheelbarrow should not be loaded more than half of its capacity. The hauling distance when using wheel barrows should not be 200m.
- Space for unloading the asphalt from one wheelbarrow to another should be known and marked before unloading the asphalt. The spacing should be calculated base on quantity of the mixed asphalt in each wheel barrow with thickness and width of asphalt to be spread. The asphalt should be unloaded in middle between the two guide rails.
- Spreading shall be commenced immediately after unloaded the asphalt from the wheel barrows. The spreading commenced from heap of the asphalt toward guide rails. Ensuring the spreading level of the asphalt same as level of the guide rails. Area of adjacent to the guide rails to be filled by asphalt. Screeding will follow the spreading to ensure level of the spread asphalt is as smooth as possible.
- Once the screeding has been completed, the guide rails shall be removed to allow commencing of compaction. Roller can then commence with low speed of less than 5 km per hours and wheel of the roller to be wet by water to avoid sticky by asphalt. With 3-5 tons roller. Wedding wheels of the roller before commencing the compaction to avoid sticky the wheel. Compaction should be done for 6-8 passes. It is recommended that, rolling of first 2 passes should be done in static mod. Vibrating mod can be started from 3 pass until finish



Cleaning equipment:

- All hand tools for spreading the asphalt are continuously cleaned by using kerosene.
- Cleaning the mixture is recommended for every 2-3 mixes and before taking break. The cleaning of mixture can be done by using shovel with round blade to clean all fine asphalt stick in the mixture. Using kerosene if necessary when the sticky is too hard to remove.



Manpower:

- 1 supervisor (part time)
- 1 mixture operator
- 1 tack coating worker (part time)
- 1 part time worker for setting out guide rails.
- 1 work gang for hauling crushed aggregate and measure for mixing (size of the gang depend on demand progress of work)
- 3-6 workers for hauling the mixed asphalt (number of workers depend on demand progress of work)
- 1 work gang for spreading and screeding asphalt (size of the gang depend on demand progress of work)
- 1 roller operator.

Tools + Equipment:

- Tape Measures, 30 m and 5m
- Guide rails (hollow steel box 20mm x 20mm)
- Hammers
- Hand broom
- Spreaders
- Baskets
- Wheel barrows
- Buckets
- Concrete mixture
- Roller.
- Shovels
- steel box 30mmx50mm for screeding
- Measuring cans

Material:

- Bituminous Emulsion bituminous for tack coat 60% CSS 1 s or 1 h
- Bituminous for asphalt 65% CMS 2 h (company code E-71)
- Kerosene
- Crushed Aggregate

Quality Control:

Before activity is carried out:

- Check if the equipment: mixture and hand tools are functioning
- Make sure guide rails are in placed correctly.
- Make sure aggregates are cleaned.
- Make sure to use the correct type of bituminous emulsion.
- Make sure the temperature of the emulsion is in rank 45-60 °C

While activity is carried out:

- Make sure mixing proportion(water, emulsion, aggregate) are correct
- Make sure spreading asphalt to level of guide rails and no waving on the completion surface. In any places where appearing low spots, asphalt shall be used for filling the spots before commencing compaction.
- Make sure that compaction activities are assumed as soon as material has been spread and control passes of the rolling.
- Make sure compaction is uniform regarding rolling pattern and number of passes. Also ensure that there is always a lateral overlap of at least 20 cm from pass to pass

Final check:

- Make sure all tools and equipment have been cleaned after using
- Make sure all guide rails have been removed and continuing use to other road sections
- Make sure exceeded material(aggregate and sand) have been hauled and reused to other uncompleted sections
- Make sure remaining asphalt on completed sections or road section to be sealed are cleaned.



WORK SHEET

Modified Otta Penetration Seal

WS-15

Specification: Modified Otta Penetration seal is a seal to enable graded seal to be constructed using bituminous emulsion as binder. The work comprises application of tack coating on the primed coat, placing a graded aggregate on a bituminous emulsion tack coat at the predetermined application rate and to penetrating the aggregate layer with the bituminous emulsion and cover by sand for final layer. The aggregate graded of 9.5 mm and smaller the grading of which falls within the grading envelope. The aggregate shall be free of dust and organic material.

Work Method:

- Setting guide rails along edges of the road with a sufficient length for tack coating. Open width of the guide rails shall not be less than designed road carriage way. Place reinforced paper or plastic sheet at starting and finishing points and at joint.
- Protect all road furniture with suitable protective material when spraying emulsion.
- Two assistances, holding 2 steel protective screens over the guide rails, follow the spraying operator of the tack coating. The protective screens shall be placed and roll over the guide rails along the road edges.
- Using protective screens to keep spraying within road area and to keep neat road edges. Two assistance holding protective screens. The protective screens shall be placed and roll over the guide rails along the road edges. Shaking emulsion before starting application of the prime. While spraying the tack coat, two person assist the spraying operator to move the motorized sprayer. The spraying shall be carried out backward in a speed depend on application rate. Bituminous emulsion for the priming should be CSS-60 1s. The emulsion shall be diluted with additional water at a rate of 1:1. Application rate of the tack coat shall be 0.6 -0.7 litre /m²
- The different fractions of crushed aggregate to be used for the sealing work shall be placed along the road. Spacing of heaps should be determined by engineer base on predetermined application rate of the aggregate. The aggregate should be



placed on plastic sheets of 1.5m x 1.5 m to reduce wastage.

- Immediate after spraying tack coat, the stocked crushed aggregate shall be applied manually on the tack coating layer. The application rate should be specified by engineer or as specified in specification. Usually, the application rate should be 0.0097 m³/m². A shovel or baskets to be used for spreading the aggregate by twisting rapidly on the air so the aggregate will be spread uniformly. Broom will be used afterward and gently broom surface to distribute the aggregate uniformly cover all area of tack coat surface.
- After the surface has been covered with the aggregate, rolling can be commenced. The compaction should start from road edge toward the centre line of the road. Rolling of 2-3 passes of static mod of 3-5 tons roller is recommended. Continue rolling by using vibrating mod of 3-4 passes before allowing next application of emulsion
- Next layer of bituminous emulsion to be applied immediate after compaction. Similar method of applying as for the tack coat, and with assistants carrying the protective screen and follow the emulsion sprayer
- The emulsion operator spraying the emulsion backward. Application rate of emulsion bituminous should be 2.4 litre /m² with emulsion 60% CSS 1 s.
- While the emulsion bituminous is setting the last layer sand shall be spread at an amount rate of about 0.002 m³/m². The application of sand shall be done uniformly and cover all areas of the emulsion bituminous. Using broom to sweep the sand uniformly
- Apply compaction immediately using 3-5 tons roller for a minimum of 5 passes at a speed of not more than 5 km/h.
- Removing of steel guide rails after spreading of sand and use for further road section.

Cleaning equipment:

- after spraying prime coat, the hand sprayer shall



be cleaned follow steps bellow: ○ pour kerosene in a 20 litre container(or bucket) ○ place the suction end of pump into the 20 litre container and nozzle of the sprayer into another empty bucket ○ start engine of the sprayer and allow the kerosene to run through the and sprayer system until clean.		
 Penetration Spray, Application Rate = 2.40 liter/m² Continuous graded aggregate Tack Coat Application Rate = 0.60 liter/m² 		
Manpower: • 1 supervisor (part time) • 2 helpers holding protective screens • 1 emulsion hand spraying operator and 2 helpers • 2 helpers holding protective screens • 1 part time worker for setting out guard rails. • 1 work gang spreading and hauling crushed aggregate and sand • 1 roller operator.	Tools + Equipment: • Tape Measures, 30 m and 5m • Guard rails • Metal proactive screen • Hammers • Hand broom • Hand sprayer • Spreaders • Baskets • Wheel barrows • Roller.	Material: • Emulsion bituminous 60% CSS 1 s • Kerosine • Sand • Crushed aggregate
Quality Control: Before activity is carried out: While activity is carried out: • Check if the equipment: emulsion sprayer are functioning • Make sure guide rails are in placed correctly. • Make sure sand and aggregate are in correct properties and that aggregate and sand is free from dust, dirt and clay. • Make sure to use the correct type of bitumen. • Are hand tools in good condition? • Make sure the temperature of the emulsion is in rank 45-60 °C • Make sure the bitumen application spray rate is sufficient; i.e. measure emulsion drum before and after using. Amount of the emulsion divide with road area covered.		

- Make sure the bituminous emulsion application spray as uniform as possible
- Make sure to spread crushed aggregate uniformly, and that the correct size of aggregate and thickness of each layer is controlled..
- Make sure that compaction activities are assumed as soon as material has been spread.
- Make sure compaction is uniform regarding rolling pattern and number of passes. Also ensure that there is always a lateral overlap of at least 20 cm from pass to pass

Final check:

- Make sure road surface is even and well compacted.
- Make sure all tools and equipment have been cleaned after using
- Make sure all guide rails have been removed and continuing use to other road sections
- Make sure exceeded material(aggregate and sand) have been hauled and reused to other uncompleted sections

	WORK SHEET
Emulsion Treated Base (ETB)	WS-16
Specification: The activity comprises provision of selected material (crushed aggregates + crusher dust) of class “A or B” and emulsion bitumen. The class “A or B” material shall be selected with correct properties referring to grading and strength according to material specification, and shall be free of lumps of organic or other deterious materials. Steel shutters and bulking rails are to be used as formwork for base material and ETB spreading activity. The work comprises spreading aggregated base, mixing of the ETB, hauling and placing the ETB on aggregates base and compaction. The mixing of the ETB shall be in accordance to mixing proportion determined by engineer and/or specified in the specification. Mixing the ETB should be done using a concrete mixer.	
Work Method: • Erects steel shutter (L- sharp steel of 10cm x 10 cm) and steel bulking rail (extended on top of the steel shutters prefer 4 cm height = loose thickness of the ETB) at road edges and centre line. The steel shutter shall be erected at centre line and at both road edges. Level of steel shutter at the centre line shall be 4% higher than the edges meaning camber of the road is 4%. Use line level to transfer shutter level and set the camber of the road. The steel shutter at the edges should be extended 20 cm outside the road edges. The steel shutter shall be fixed to the road base with steel pegs for every 1.5- 2.0 m Note: Spreading shall be divided into two steps: 1- Spreading base course of 10 cm loose thickness 2- Spreading ETB on the base of 4 cm loose thickness • Deliver selected base course materials(class A or B) along the road. The engineer should inspect approve quality of material before it is delivered. Laboratory testing (sieve analysis and CBR) of the material is needed. Distance from one heap to other of material to be delivered should be calculated based on designed base thickness and width of the base and quantity of material of each truck.	

Ex: - 1 truck= 4 m³ of gravel

=> carriage way width=3 m; base width 3.4 m

=> compacted thick 10 cm or loss thickness

$$\text{distance between heaps} = \frac{4 \text{ m}^3}{3.4 \times 0.1} = 11 \text{ m}$$

- Spread the aggregate to level of steel shutter (at bottom level of bulking rails) by labours with proper hand tools like: spreaders, shovels, wheel barrows, hoes and baskets.
- Applying water uniformly to get optimum moisture contain. Water content should be between 4-7% of the mass depending moisture contain in the aggregates.

Placing mixture and aggregate:

- The mixture should be placed as close as possible to the determined areas for unloading the mixed ETB to avoid longer hauling. Aggregates for the mixing should be deposited close to the mixer. Use buckets for measuring aggregate, emulsion bitumen and cement prior mixing.

Mixing the ETB:

- Use measuring cans add correct amount of aggregate to the mixture while the mixing drum is operating. Proportion of the mix shall be determined by engineer or as specified in the technical specification. Water is then added slowly to the drum and continuously mixing until the aggregate is thoroughly dampened. Amount of the water should be 4-7 % of mass of the aggregate.
- Add Portland cement into the drum continuously while the mixer is operating. Composition of the aggregate and cement shall be predetermined by the engineer or specified in the technical specification. In common case, the proportion of cement should be 1.5-2.5% in mass of the ETB
- Add bituminous emulsion of CSS-60 slowly pour into the drum continuously while the mixer is operating. The mixer should be operated as slowly as possible. Composition of the aggregate and emulsion shall be predetermined by the engineer or specified in the technical specification. In common case, the proportion of bituminous emulsion should be 1.5-2.5% in mass of the ETB



Note: The drum of the mixer should not be filled more than half its volume.

- Immediately after the mixing, the ETB should be discharged to wheel barrow and hauled to location where it will be spread. The hauling distance for the wheel barrow shall not be greater than 200m.
- Spreading the ETB shall be commenced immediately after unloaded the mixed ETB from the wheel barrows. The unloaded ETB shall be spread uniformly to top level of the bulking rails. Screeding will follow the spreading to ensure level of the spread ETB as smooth as possible.
- Once the screeding has been completed, compaction shall be commenced by roller. First 2-3 passes (for roller capacity 3-6 tons) of compaction should be done without vibration. Final compaction should be follow for another 8-10 passes with vibrating mode.

Full compaction or number of passes of compaction can be determined through tests or determined at the field by watching settling of compacted section to bottom level of bulking rails. Usually 8 to 10 passes with 3-6 tons roller are sufficient if the moisture content is optimal.

- Once the compaction has been completed, the steel shutters and bulking rails can then be removed
- Shoulder should be filled immediately after removal of the shutters and bulking rails and immediately watered and compacted.

Note: The spreading can be done half or full width of the road depending on the traffic.

Cleaning equipment:

- All hand tools have been used for spreading the ETB and mixture shall be cleaned before taking long break or completion of activity.
- Cleaning the mixture and tools should be done by using kerosene if necessary when emulsion bitumen sticky is too hard to remove.



Note:

- The aggregated used for road base and ETB can be selected material class “A or B” depending on budget available and required CBR.
- If design for using selected material class “C, additional clay content of 20-25% is required.



Manpower:

- 1 supervisor(part time)
- 2 part time workers for setting out and erect shutters and bulking rails.
- 1 work gang spreading and hauling the gravel
- 1 work gang(3-4) for hauling crushed aggregate and measure for mixing (size of the gang depend on demand progress of work)
- 3-6 workers for hauling the mixed ETB (number of workers depend on demand progress of work)
- 1 work gang for spreading and screeding asphalt (size of the gang depend on demand progress of work)
- 1 roller operator.

Tools + Equipment:

- tape Measures: 30 m and 5 m
- steel shutters(L-steel 10cm x 10 cm), bulking rails(steel 40mm) and steel pegs
- screeding steel box 50 mm x 100 mm
- hammer
- spreaders, shovels
- baskets
- wheel barrows
- vibrating roller
- line level and fishing line
- water buckets
- mixture

Material:

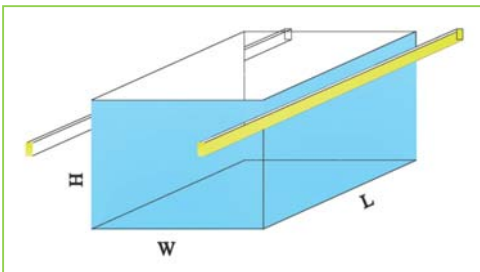
- selected base course material class “A or B”
- emulsion bitumen CSS-60
- cement

Quality Control:

Before activity is carried out:

- Is setting out done correctly? Are the steel shutters and bulking rails erected properly?
- Make sure selected material has been tested. If basic laboratory equipment is available CBR test and Sieve analyze should be made.
- Are hand tools in good condition?
- Make sure road width is cleared before the activity is started, and ensure

	that the area is free of trees, bushes, shrubs, grass and roots before filling & compaction. • Make sure to use the correct type of bituminous emulsion.
While activity is carried out:	• Make sure the gravel for road base has been spread to bottom level of the bulking rails in all areas • Make sure watering has been uniformly sprayed before unloading the mixed ETB • Make sure the ETB has been spread to top level of bulking rails • Make sure compaction is uniform by counting number of passes and ensure that there is always a lateral overlap of at least 20 cm from pass to pass.
Final check:	• Make sure the road surface is even, and that no soft spots are left after compaction. • Make sure all tools and equipment have been cleaned after using • Make sure exceeded material(aggregate and sand) have been hauled and reused to other uncompleted sections
Suggested Productivity: • Spreading and hauling aggregate for road base is 5-7 m³/ Wd • Mixing, hauling and spreading ETB is 10 m²/Wd	

	WORK SHEET
Stone masonry work	WS-17
Specification: Stone masonry is a collective term describing the assembly of stones using mortar. The work includes supply of all materials, preparation of foundations and all other works necessary to complete the structure in accordance with specifications shown on drawings or as instructed by contract supervisor. Stone masonry can be used for structures such as retaining walls, abutment of small bridges, slab culverts and culvert head walls and wing walls, lining the sides and bottom of ditches and water ways, and of constructing aprons.	
Work Method: • Set pegs as reference for foundation, and tie a string along the pegs. • Excavate for foundation to designed depth. Excavation to any other depth shall be approved by the supervisor. • Compacted stone shall be placed at the bottom of foundation, followed by a lean concrete layer. • When mixing cement mortar, proportion of the cement shall be in accordance with the manufacturer's specification. Cement mortar shall be mixed using a concrete mixer. To measure the correct mixing proportions, a measuring wooden box should be used. • Water cement ratio should be 0.4-0.5= 20 to 25 litres of water for 50 kg of cement. Placing of Stone • Set pegs and strings to provide the correct levels and to get the stone surface even. • Large stones shall selected and be used for the bottom layer and in the corners. Stones shall be laid with their longest face horizontal and the exposed face of individual stones shall be set parallel to the face of the wall in which the stones are set.	  

Placing of Mortar

- Prior to being placed, the stones shall be cleaned and thoroughly wetted. The cement mortar shall be placed before and after placing each piece of stone. In big gaps between stones, small hard stones should be fitted and filled along with cement mortar. The thickness of cement mortar shall be in the range of 2 to 5 cm and shall be the minimum necessary to ensure the filling of all voids between the placed stones.

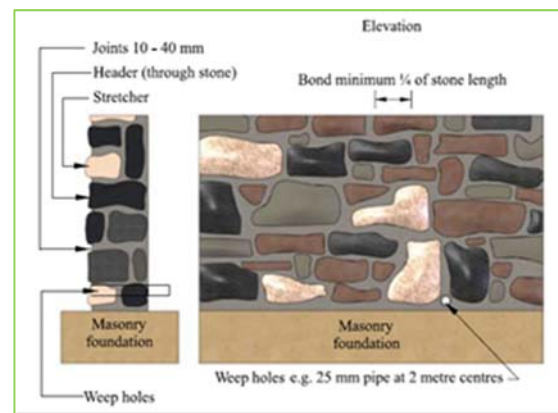


Curing

- Finished surfaces shall be cured immediately after mortar has started to harden by spraying with water. The total time period of curing shall be applied as specified in the specification, or as instructed by the contract supervisor

Plastering Works

- If instructed by the contract supervisor or if it is indicated in the drawing, the finished stone masonry surface should be covered with a smooth plaster. Generally, a 15 mm thick plaster layer, with cement mortar proportion of minimum 1:3 (1 unit of cement to 3 units of sand), is sufficient.



Manpower:

- 1 Supervisor (part time)
- Masons for stone masonry work
- Mason helpers (unskilled workers)

Tools + Equipment:

- Tape measures, 30 m and 5 m
- String line and pegs
- Concrete mixer
- Shovels
- Hoe
- Hammers
- Buckets
- Measuring box
- Wheel barrows

Material:

- Sand
- Hard stone
- Portland cement
- Water

Quality Control:

Before activity is carried out:

- Is setting out done correctly?
- Are pegs and string line placed correctly?
- Is camber board used?
- Make sure to use cleaned and durable sand and stones.

While activity is carried out:

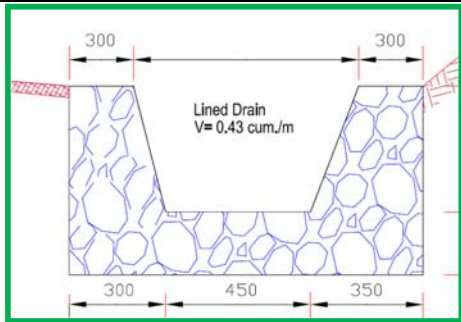
- Make sure the cement is in good quality.
- Make sure the excavated trench is dry before starting foundation structure works.
- Make sure mortar mixture proportions are correct (cement, sand and water).
- Make sure a strong pattern of placing stones is used.
- Make sure all gaps are filled with mortar.
- Give special attention to joints/ pointing. If those are properly done, the technique can be alternative to plastering.

Final check:

- Make sure pointing or plastering is properly done.
- Make sure curing is made before cement mortar has dried.

Suggested Productivity range: 1.5 - 2 m³ / wd

	WORK SHEET
Stone masonry lined drain	WS-18
Specification: The stone masonry lined drain is constructed to drain out water from road carriage way along the road, to a designated water stream or road cross drainage structures The work consists of supplying all materials, excavating side drain and stone masonry wall and bedding. The work shall be performed in accordance with specifications and drawings, or as required in writing by the contract supervisor.	
Work Method: • Survey and choose gradient to ensure free drainage. • Set pegs as reference for foundation and tie string along the pegs. • Excavate side drain walls and foundation to designed width and dept. • When mixing cement mortar, proportion of the cement shall be in accordance with the manufacturer's specification. Cement mortar shall be mixed using a concrete mixer. To measure the correct mixing proportions, a measuring wooden box should be used. To measure the correct mixing proportion, a measuring wooden box should be used. Water cement ratio should be 0.4-0.5= 20 to 25 liters of water for 50 kg of cement. • Set out pegs and strings for stone masonry works. Large stones shall be selected and used for the bottom slab. Stones shall be laid with their longest face horizontal and the exposed face of individual stones shall be set parallel to the face of the wall in which the stones are set. • Cement mortar shall be placed before and after placing each piece of stone and fill all the gaps. The thickness of cement mortar shall be in the range of 2 to 5 cm and shall be the minimum necessary to ensure all voids between the placed stones are completely filled. • In big gaps between stones, small hard stones should be fitted and filled along with cement mortar. • The finished surface stone masonry work shall be covered with a smooth plaster (if specified in the drawing). Generally, a 15 mm thick plaster layer, with cement mortar proportion of minimum 1:3 (1 unit of	  

cement to 3 units of sand), is sufficient. The finished stone masonry work shall be cured immediately after mortar have started harden by application of water and providing cover using cloth bags or sacks. The total time period of curing shall be applied as specified in the specification, or as instructed by the contract supervisor .								
Manpower: 1 Supervisor (part time) 1 Work gang for excavation of side drain - Masons for stone masonry work - Mason helpers (unskilled workers)	Tools + Equipment: - Tape measures, 30 m and 5 m - String line and pegs - Concrete mixer - Shovels - Hoe - Hammers - Buckets - Measuring box - Wheel barrows	Material: - Sand - Hard stone - Portland cement						
Quality Control: <table><tr><td>Before activity is carried out:</td><td> - Is setting out done correctly? - Are pegs and string line placed correctly? - Is camber board used? - Make sure to use cleaned and durable sand and stones. - Make sure the cement is in good quality. </td></tr><tr><td>While activity is carried out:</td><td> - Make sure the excavated trench is dry before starting foundation structure works. - Make sure mortar mixture proportions are correct (cement, sand and water). - Make sure all gaps are filled by mortar - Give special attention to joints/ pointing. If those are properly done, the technique can be an alternative to plastering. </td></tr><tr><td>Final check:</td><td> - Make sure pointing or plastering is properly done. - Make sure curing is made before cement mortar has dried. </td></tr></table>			Before activity is carried out:	- Is setting out done correctly? - Are pegs and string line placed correctly? - Is camber board used? - Make sure to use cleaned and durable sand and stones. - Make sure the cement is in good quality.	While activity is carried out:	- Make sure the excavated trench is dry before starting foundation structure works. - Make sure mortar mixture proportions are correct (cement, sand and water). - Make sure all gaps are filled by mortar - Give special attention to joints/ pointing. If those are properly done, the technique can be an alternative to plastering.	Final check:	- Make sure pointing or plastering is properly done. - Make sure curing is made before cement mortar has dried.
Before activity is carried out:	- Is setting out done correctly? - Are pegs and string line placed correctly? - Is camber board used? - Make sure to use cleaned and durable sand and stones. - Make sure the cement is in good quality.							
While activity is carried out:	- Make sure the excavated trench is dry before starting foundation structure works. - Make sure mortar mixture proportions are correct (cement, sand and water). - Make sure all gaps are filled by mortar - Give special attention to joints/ pointing. If those are properly done, the technique can be an alternative to plastering.							
Final check:	- Make sure pointing or plastering is properly done. - Make sure curing is made before cement mortar has dried.							
Suggested Productivity range: - Excavation: 1.5-2 m³ / wd - Stone masonry work: 1.5 – 2 m³ / wd.								

LBT Training Manual

Index & References

Table of Contents, Module P Index and References

Detailed Contents..... 3

References..... 6

Detailed Contents

Introduction 12p

Foreword

Acknowledgement

1 Introduction

- 1.1 The road network in Timor-Leste
- 1.2 The Importance of Good Access
- 1.3 Strategy
- 1.4 Project Management

2 Technology Choice

3 Training

- 3.1 Overall training Programme

4 This manual

A Mensuration 10p

- A-1 Length
- A-2 Area
- A-3 Volume
- A-4 Weight and capacity
- A-5 Slope
- A-6 Pressure
- A-6 Unit conversation

B Soil 7p

- B-1 Introduction
- B-2 Terminology and definitions
- B-3 Soil characteristics
- B-4 Summary soil classification
- B-5 Identification of soils
- B-6 Characteristics of soil for road work

C Labour-Based Technology [LBT] 16p

- C-1 Labour issues
- C-2 Hand tools
- C-3 Tools for setting out and quantity surveying
- C-4 Quantities of hand tools and survey instruments for Labour-Based road works
- C-5 Light equipment

D Road terminology 7p

- D-2 Typical cross section

E Work organisation 24p

- E-1 Work site organisation
- E-2 Labour recruitment for LBT road works
- E-3 Incentive payment system
- E-4 Planning

E-5 Construction sequence

E-6 Work gang balancing

E-7 Instructions

E-8 Inspection of works

E-9 Establishment of site camp

F Setting out 21p

- F-1 Selection of road alignment
- F-2 Setting out straight lines
- F-3 Setting out horizontal curve
- F-4 Setting out vertical alignment
- F-5 Setting out cross section
- F-6 Set out cross section side drain and camber in rolling terrain
- F-7 Set out cross section road in mountainous terrain
- F-8 Set out cross section of embankment (road in flat terrain)

G Earth works 17p

G-1 Clearing

- G-1-1 Bush clearing
- G-1-2 Boulder removal
- G-1-3 Grubbing and top soil removal

G-2 Construction of earth works

- G-2-1 Leveling
- G-2-2 Construction side drain and camber
- G-2-3 Cut and fill
- G-2-4 Construction of embankment
- G-2-4 Sloping
- G-2-5 Compaction
- G-2-6 Planting Grass

G-3 Quality control for earth works construction

G-4 Safety and health for earth works construction

H Drainage 11p

- H-1 Catch water drains
- H-2 Scour checks
- H-3 Mitre drains
- H-4 Surface drains
- H-5 Cross drainage structures

I Graveling 15p

- I-1 Gravel
- I-2 Planning for the graveling operation
- I-3 Preparation of gravel quarry
- I-4 Excavation and loading gravel
- I-5 Hauling gravel

- I-6 Work procedures
- I-7 Off loading gravel
- I-8 Spreading gravel
- I-9 Watering and compaction of gravel
- I-10 Dynamic Cone Penetrometer
- I-11 Gradation test
- I-12 Quality control for graveling work
- I-13 Safety and health for graveling work

J Surface options 28p

- J-1 Type of surfaces
- J-2 Layers of road pavement
- J-2 Sub-base
- J-3 Road base course
- J-4 Bituminous surface
- J-5 Application of prime coat
- J-6 Penetration Macadam (Pen-Mac) surface
- J-7 Construction of plum concrete surface
- J-8 Stone surface
- J-9 Safety and health

K Concrete and Stone masonry work 17p

- K-1 Concrete
 - K-1-1 Material for concrete
 - K-1-2 Types of concrete
 - K-1-3 Mixing concrete
 - K-1-4 Transporting concrete
 - K-1-5 Placing concrete
 - K-1-6 Compaction of concrete
 - K-1-7 Curing concrete
 - K-1-8 Slump test
 - K-1-9 Quality Control
- K-2 Stone masonry
 - K-2-1 Material for stone masonry works
 - K-2-2 Mortar for stone masonry works
 - K-2-3 Joint and bond for stone masonry works
 - K-2-4 Weep holes
 - K-2-5 Quality control

L Culvert, Lined drain, drift, gabion 37p

- L-1 Culverts
 - L-1-1 Introduction
 - L-1-2 Typical Culvert Features
 - L-1-3 Culvert Location
 - L-1-4 Positioning of a culvert
 - L-1-5 Setting out
 - L-1-6 Construction of box culvert
 - L-1-7 Quality control

L-2 Stone masonry lined side drains

- L-2-1 Introduction
- L-2-2 Construction material
- L-2-3 Tools and equipment
- L-2-4 Work Method
- L-2-5 Quality control
- L-3 Drift
 - L-3-1 General Introduction
 - L-3-2 Selection location for a drift
 - L-3-3 Main features of a drift

- L-3-4 Design considerations for the drifts
- L-3-5 Construction
- L-3-6 Quality control

L-4 Gabion works

- L-4-1 Construction of gabion structures
- L-4-2 Quality Control For Gabion works

L-5 Safety and health for drainage structures**M Cross cutting issues 18p****M-1 Gender and women's participation in LBT road works**

- M-1-1 Gender training
- M-1-2 Gender sensitization
- M-1-3 Recruitment of workers
- M-1-4 Gender consideration during implementation

M-2 HIV/Aids awareness**M-3 Environmental issues**

- M-3-1 Mainstreaming environmental issues in LBT road works
- M-3-2 Environmental mitigation measures during road construction

M-4 Occupational Safety and Health (OSH)

- M-4-1 Safety and health office
- M-4-2 Safety at work
- M-4-3 Examples of Accidents
- M-4-4 Causes of Accidents Re Write
- M-4-5 Safety on Site
- M-4-6 Health at work

N Reports and site administrative form 18p

- Employment Registration Form
- Muster/Payroll
- Overall/Daily site planning and actual record
- Weekly Site Report

Monthly Progress Report
Monthly Work Plan & Physical Progress
Fuel Distribution Record
Fuel Stock Record
Tools Stock Record
Site Equipment Log Book
Quantities Earth Work and Gravel
Quantities Structures

O Work Sheets 52p

Site clearing / bush and grass clearing
Filling sub-Base selected class C material (or natural gravel)
Telford base
Road base course with different stone sizes (Macadam)
Base course with selected class A material (crushed aggregate mixed with aggregate dust)

Pothole patching
Prime Coat
Penetration Macadam Pavement
Sand Seal Pavement
Road shoulder repair
Filling base course (use steel shutter system)
Prime coat using bituminous emulsion
Cold mix asphalt (manual mixing of asphalt)
Cold mix asphalt (using concrete mixer)
Modified Otta Penetration Seal
Emulsion Treated Base (ETB)
Stone masonry work
Stone masonry lined drain

References

Technical Manual for Labour-Based Road Construction Methods, Bjorn Johannessen, MRD-RIIP-IT Transport, Phnom Penh, July 1998.

Building Rural Roads, Bjorn Johannessen, ILO, 2008.

Labour – Based Road Works, Intech Beusch and Tomas Stenstrom, Zambia, 2004.

Contractor's Field Hand book, Road Improvement Works, Intech Beusch, Republic of Ghana, August 2006

Technical Manual for Rural Roads, Lesotho, 1991.

Entrepreneurship Development for Labour Based road construction contractors, Lesotho, 1999

Technical Manual, Uganda, May 2004

Increased Application of Labour-Based Methods Through Appropriate Engineering Standards, ILO

Implementing employment intensive road works. Practice manual Contributing to contractor development in job creation, cidb

Labour Intensive Construction, Repair and Maintenance of Structures, CETA

ILO-Labour Regulation and Recruitment

ILO-Technical Manual for Small scaled contractors using LBAT Technology for rural road construction, Cambodia. ILO-CMB/97/M02/SID. 2002

Environmental Protection Guidelines for the Roads in Timor Leste, RDP 3, May 2012

Labour-based rural road work manuals for training provided by Don Bosco Training Center



International
Labour
Organization



Training modules developed through the Enhancing Rural Access Project, with technical support from the ILO and funding from the European Union and the Government of New Zealand