THE REPUBLIC OF UGANDA

District Road Works

VOLUME 1

Technical Manuals

Manual A:

Technical Manual

Ministry of Works, Housing and Communications

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ACKNOWLEDGEMENTS

These manuals have been prepared by the Ministry of Works, Housing and Communications, Uganda.

The aim of the manuals is to complement the Ministry's effort in providing guidance and building capacity of Local Governments to enable them handle their mandated roles in planning and management of the road sector development.

This manual is part of a set titled District Road Works. The set consists of 5 Volumes, each volume comprising a series of manuals covering varying aspects under the following headings:

Volume 1	Planning Manuals
Volume 2	Contract Management Manuals
Volume 3	Implementation and Monitoring Manuals
Volume 4	Technical Manuals
Volume 5	District Administrative and Operational Guidelines

The Manuals describe in detail the organization and techniques for planning, implementation and administration of a district road network. The manuals support Government strategies on sustainable maintenance of district roads; they encourage community participation, promote use of labour based methods and gender balance, ensure protection of the environment, foster work place safety and health in implementation of road works by adopting appropriate contracting practices and support the local construction industry.

They are primarily aimed at Road Engineers, Planners and Managers involved in the planning and management of district road works.
In line with the topics covered in these manuals, related training modules have been designed and are incorporated in the curriculum of the Mount Elgon Labour Based Training Centre.

The manuals are the property of the Ministry of Works, Housing and Communications, but copying and local distribution is not restricted.

We wish to acknowledge the efforts of COWI Consulting Engineers and Planners AS who assisted in the compilation of the Drafts and the invaluable support of the Danish International Development Agency for the financial assistance extended to the Ministry in preparing the manuals.

Lutaaya

L.Lutaaya

Engineer in Chief / DE

Volume 4 Manual A

Technical Manual

Table of Contents

Section A
Road Terminology

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Road Terminology

ROAD TERMINOLOGY

The terms that are used to describe the work must be clearly understood by all members from both the Employer and the Contractor's technical team. The proper use of clearly defined and well-understood terminology will avoid misunderstandings and ensure clarity of purpose.

A1 GENERAL ROAD TERMS

Earth Roads

Earth roads are formed from the insitu soil material.

Gravel Road

Gravel roads have a gravel layer as a surfacing material.

Paved Roads

Paved roads have a homogenous and strengthened carriageway surface, which consists of bitumen, concrete or other pavement materials such as stones and bricks.

Construction

The process by which a road is built according to established design standards and work methods.

Rehabilitation

Activities which restore a road's geometric characteristics to the original recommended design standards.

Upgrading

The process by which the standard of an existing road is improved to allow safe use by a greater volume of traffic than originally designed for.

Maintenance

The work required to keep the road, its structures and property within the road margins as near as possible to their as-constructed or rehabilitated condition.

A2 ROAD ELEMENTS

GEOMETRIC TERMS

Plan

Plan is what you see if you are looking from above toward the ground.

Elevation

Elevation is a view of the object as seen from the side.

Cross-Section

Cross-section is the drawing of an object as it is seen if it has been cut across.

Road Centerline

A longitudinal axis along the middle of the road.

Horizontal Alignment

Arrangement of a road on the plan view showing a series of straight lines connected by curves.

Vertical Alignment

Longitudinal section of a road referring to the surface level of the completed road along the carriageway centerline.

CROSS SECTION TERMS

Road Reserve

Strip of land legally awarded to the Road Authority in which the road is or will be situated and where no other work or construction may take place without permission from the Road Authority. The width of the road reserved is measured at right angles to the centerline of the road and varies according to the classification of the road.

Formation Width

Full width of the road, including side drains, side cuts and embankments.

Roadway

Full width of the road, including shoulders and carriageway for use by traffic.

Carriageway

Paved or unpaved width of the road, excluding the shoulders, normally used by traffic.

Shoulders

Paved or unpaved width of the road between the edge of the carriageway and the shoulder break point. The shoulder provides side support for the pavement or gravel surface and allows vehicles to stop or pass in an emergency.

Shoulder Break Point

The point where the roadway and the ditch inside slope or embankment slope meet along the sides of the road.

Camber

The lateral slope(s) of the cross-section of the carriageway and shoulder, constructed to drain the rainwater from the carriageway to the side drains.

Crossfall

The difference in level measured traversely across the surface of the carriageway expressed as a percentage (%).

Crown

Peak or highest point of the cross-section of a cambered carriageway.

Road Surface

The top layer of the pavement on a paved road. It consists of wearing course and sometimes a a base course or binder course. On the gravel road, it is the gravel surface.

Pavement

The part of a road designed to withstand the weight or loading by traffic.

Subgrade Surface

Constructed upper layer of the natural or imported soil (free from unsuitable material) which supports the pavement layer or gravel surface.

Road base

The pavement courses/layers between surfacing and sub-base.

Sub-base

The course between the road base course and the sub grade.

Original Ground Level

The natural ground level prior to construction of the road.

Embankment

Constructed fill material below the pavement or gravel surface raising the road above the surrounding natural ground level.

Embankment Slope

The constructed, inclined soil surface on the side of the embankment.

FIGURE 1-A2: TYPICAL CROSS SECTION OF A GRAVELLED ROAD

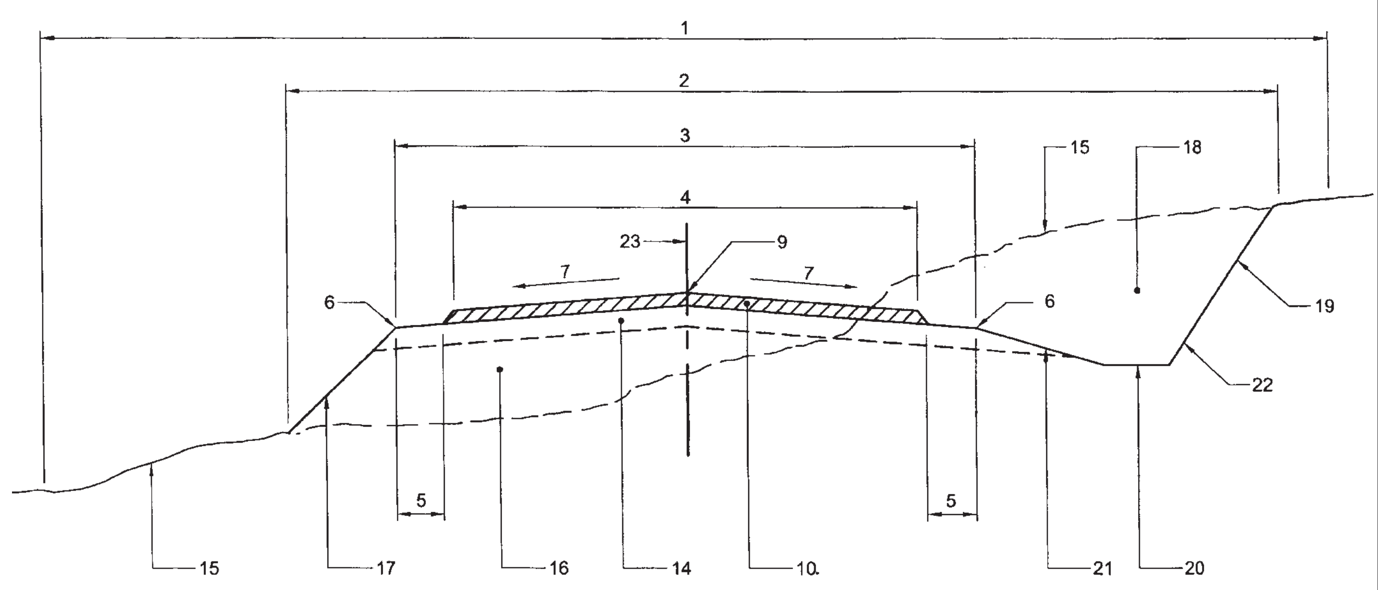
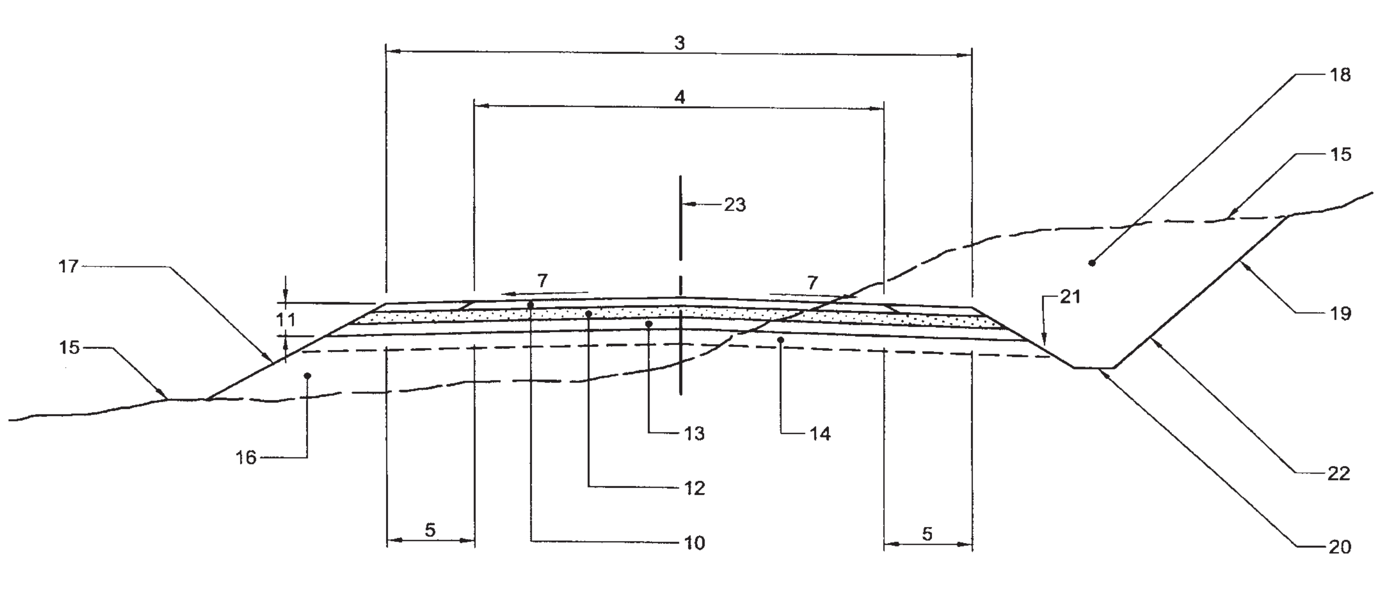


FIGURE 2-A2: TYPICAL CROSS SECTION OF A PAVED ROAD



CODING FOR FIGURE 1-A3 & 2-A3

1 - ROAD RESERVE
2 - FORMATION WIDTH
3 - ROADWAY
4 - CARRIAGEWAY
5 - SHOULDER
6 - SHOULDER BREAK POINT
7 - CAMBER
8 - CROSSFALL
9 - CROWN
10 - PAVEMENT (GRAVEL ROAD)
11 - PAVEMENT (SURFACED ROAD)
12 - ROAD BASE
13 - SUB-BASE
14 - SUBGRADE SURFACE
15 - ORIGINAL GROUND LEVEL
16 - EMBANKMENT
17 - EMBANKMENT SLOPE
18 - CUT
19 - CUT SLOPE
20 - DRAIN INVERT
21 - DRAIN INSIDE SLOPE
22 - DRAIN BACK SLOPE (OUTSIDE SLOPE)
23 - ROAD CENTRELINE

Cut

Excavation in the natural ground with graded slope to accommodate the road.

Cut Slope

The constructed inclined soil surface in a cut.

Drain Invert

The lowest surface of the internal cross section of a drain.

Drain Inside Slope

The slope from the shoulder break point to the inside edge of the side drain invert.

Drain Back Slope (Drain Outside Slope)

The outer slope of the side drain with an appropriate angle to prevent soil from sliding into the ditch.

Superelevation

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

A3 DRAINAGE TERMS

Side Drain

Long flat-bottomed excavation running along the road side, designed to collect and drain surface runoff water from the carriageway and adjoining land, away from the roadway to a suitable point of disposal.

Mitre Drain

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

Catch Water Drain

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

Scour Check

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

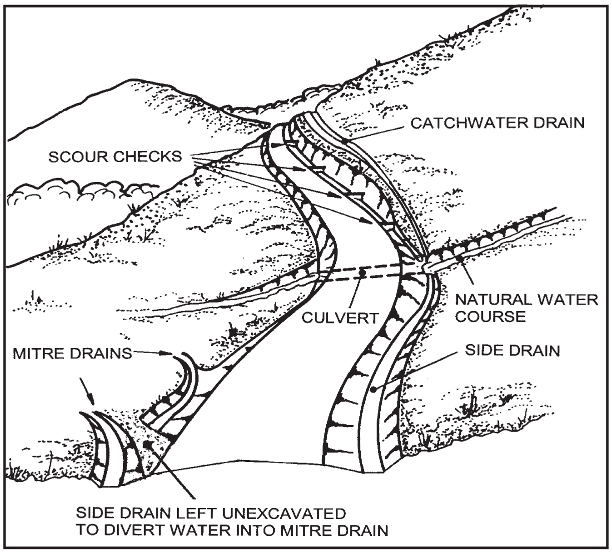
Headwalls

Retaining wall at the entry or exit of the culvert to retain and protect the embankment or retained soil/gravel.

Wingwalls

Retaining wall at the side of the culvert or large structures to retain and protect the embankment or retained soil.

FIGURE 1-A3: DRAINAGE COMPONENTS



Apron

The flat paved area at the culvert inlet or outlet to prevent erosion.

Cutoff Wall

A vertical wall under the headwall to prevent water seeping under the structure and undermining it.

Invert

The lowest point on the cross section through the culvert opening. This usually varies through the length of the culvert.

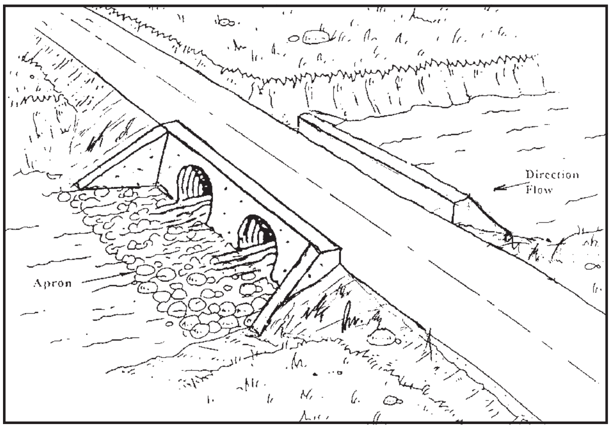
Gradient

This is the longitudinal slope of the culvert invert, typically between 2% and 5%.

Culvert

The culvert is a 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.

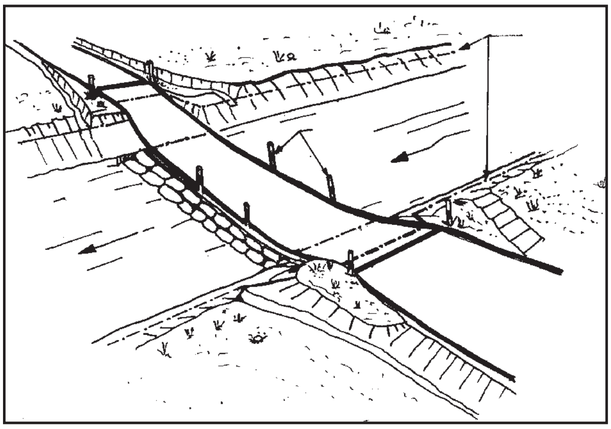
FIGURE 2-A3: CULVERT



Drift (Ford)

Drift is a low level structure constructed to allow water from the drains and/or natural water course to safely cross over the road at bed level.

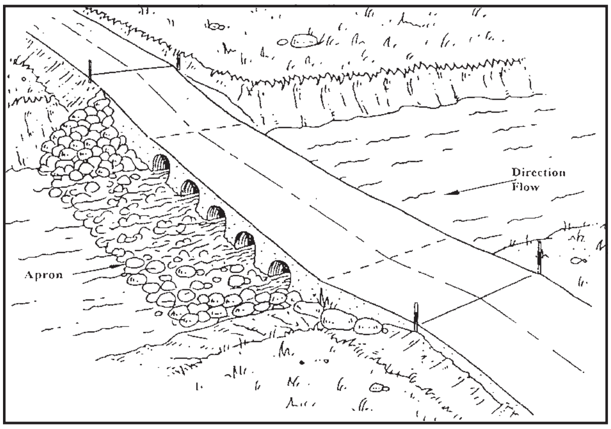
FIGURE 3-A3: DRIFT



Vented Ford (Vented Drift or Causeway)

Vented ford/drift 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.

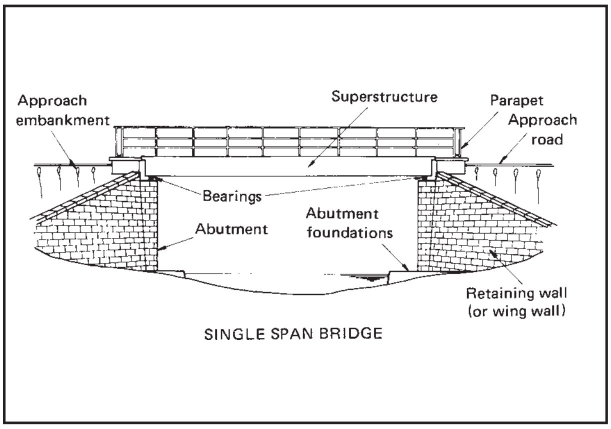
FIGURE 4-A3: VENTED FORD



Bridge

A structure providing a means of crossing safely above water, railway or other obstruction whether natural or artificial.

FIGURE 5-A3: BRIDGE



Section B

Standard Design

Section B
Standard Design

STANDARD DESIGN

B1 THE FUNCTIONAL ROAD CLASSIFICATION SYSTEM

The categorization of a road is based on its proposed function and the level of service its to provide. This subject is discussed in detail in District Road Works Manual **Volume 1 Manual A**.

NATIONAL FUNCTIONAL ROAD CLASSIFICATION SYSTEM

The roads in Uganda may be divided into the following functional classes according to their major function within the road network:

Trunk Roads (Classified Roads)

- Fall under the responsibility of the Ministry of Works, Housing and Communications.

District Roads (Feeder roads)

- Fall under the responsibility of District Local Governments.

Urban Roads

- Fall under the responsibility and within the boundaries of Urban Authorities as defined by the Urbanised Area Map Gazette.

Community Access Roads

- Fall under the responsibility of Sub-County (LC-3) administrations.

  Within each of these four principal functional classes, there are a number of design classes, which generally reflect the usage of the road by the public.

FUNCTIONAL ROAD CLASSIFICATION SYSTEM FOR DISTRICT ROAD NETWORKS

District Class I Roads

- Serve national interests in that they satisfy criteria established for secondary and/or tertiary road systems within the Trunk Road system.
- Qualify for upgrading to Trunk Road system provided they are engineered and constructed to Ministry of Works, Housing and Communications standards.
- Refer to **Section B3** for applicable cross sections.

District Class II Roads

- Provide the basic internal transport needs of the district.
- Connect to the trunk road network and district class 1 road.
- Interconnect the district capital and county administrative centres.
- Provide direct access for district population centres to district service facilities.
- Earth or gravel surface carrying 20 or more vehicles per day.
- Refer to **Section B3** for applicable cross sections

District Class III Roads

- Low volume traffic extending into sparsely populated peripheral areas of the districts.
- May serve as connectors to and/or between district class II roads, but generally do not provide direct routings to major public activity centres.
- Earth or gravel surface carrying less than 20 vehicles per day.
- Refer to **Section B3** for applicable cross sections

DESIGN CLASS AND STANDARDS

Design standards are directed by the road functional class, together with other indicators such as existing and predicted levels of motorized traffic using the road, i.e. the higher the traffic volume, the higher the design class and design standard of the road.

Design class serves as a guide for the selection of appropriate geometric design standards for road construction and subsequent levels of routine and periodic maintenance.

Roads have two basic roles, namely to provide mobility (speed) and access. The more the access-giving role is pronounced, the less the mobility of the road becomes and vice-versa.

However, geometric design standards are inextricably linked to the design speed of a road. For the purposes of designing the geometric alignment of a road, a design speed must be assigned. Generally, the higher the design class the higher the design speed that can be assumed. It follows, therefore, that the higher the design class of a road, the higher the geometric standards become.

It must be emphasized here that this does not mean that speed (mobility) is a more important role than the access of a road. The speed criterion only gives a means of relating the road class to the appropriate geometric standard.

The table below gives the relationship between road class, design speed, traffic volumes, grades and road widths.

TABLE 1 - B1: DESIGN SPEEDS, TRAFFIC VOLUMES, GRADES AND ROAD WIDTHS ACCORDING DISTRICT ROAD CLASSES

Road Class	Traffic Volume (vpd)	Max. Grade (%)	Design speed depending on terrain condition (km/hr)			Carriageway Width (m)	Road Reserve (m)
			Flat	Rolling	Hilly		
I	> 50	10	70	60	50	6.0 - 7.4	15 - 30
II	20 - 50	12	60	50	40	4.5 - 5.8	15 - 25
III	< 20	15	50	40	30	4.0 - 5.4	15 - 18

DEFINITIONS OF DIFFERENT TYPES OF TERRAIN

Flat terrain

- 0 ~ 10 five metre ground contours per kilometre
  (i.e. 0 ~ 5% gradient)

Rolling terrain

- 11 ~ 25 five metre ground contours per kilometre
  (i.e. greater than 5% gradient but not more than 12.5% gradient)

Hilly terrain

- Greater than 25 five meter ground contours per kilometre
  (i.e. greater than 12.5% gradient)

B2 ALIGNMENT STANDARDS

The vertical and horizontal alignment criteria are specified for District roads in order to make the improved roads safe and compatible with the "**all weather**" requirements.

SIGHT DISTANCES

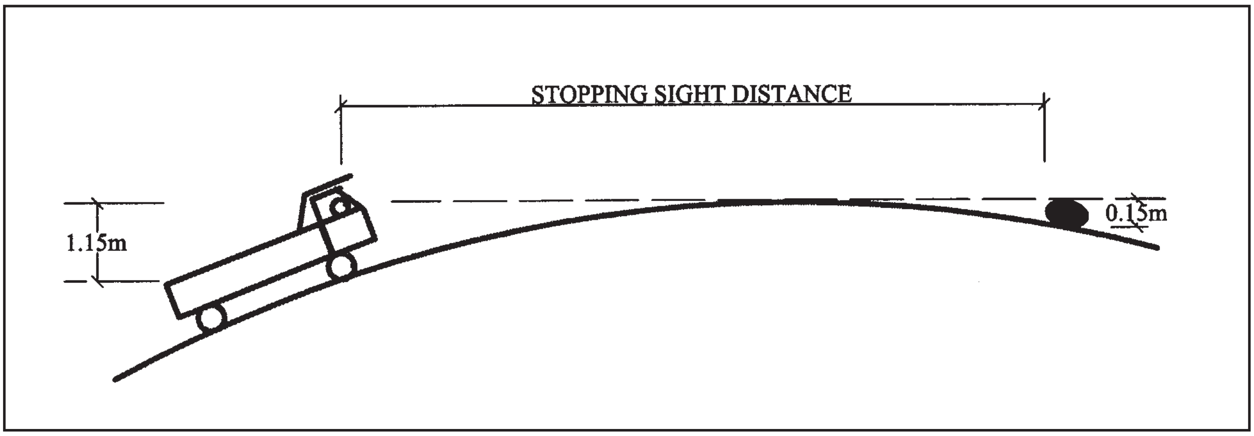
The length of a driver's visibility along a road in the direction of travel is termed his sight distance. In road alignment design, there are two sight distance criteria to be met, namely, the safe stopping sight distance and the passing sight distance.

Safe Stopping Sight Distance

The safe stopping sight distance is the driver's range of view, in his/her direction of travel, which allows him/her to see a stationery object in his lane of travel and stop before striking it.

This distance shall be provided at all times for a vehicle moving along the road at the design speed of the road. Where it is impossible to provide this distance, appropriate signs shall be placed on that road section to warn the traffic of the danger.

FIGURE 1 - B2: STOPPING SIGHT DISTANCE



Passing sight distance

The passing sight distance is the driver's range of view, in his direction of travel, which allows him to safely pass another vehicle travelling in the same direction without risk of collision with traffic advancing towards him.

The passing sight distance becomes less critical as the class of road decreases, particularly if they are earth or gravel roads. Passing sight distance shall be provided at reasonable intervals on all District Class I roads. For district Class II and Class III roads, the provision of passing sight distance shall be at the discretion of the District Engineer.

HORIZONTAL ALIGNMENT

Cross fall

On unpaved district roads the cross fall is designed to remove rainwater quickly and effectively. An **as built** camber of 8% is chosen to allow for consolidation of the road body over time with a minimum residual camber of 5% which is sufficient to achieve rapid shedding of rain water into the side drains. The 8% **as built** camber also ensures balance of cut and fill from a level plateau.

Horizontal curves

For small changes of direction, it is desirable to use large radius curves. This improves the appearance of the road by removing rapid changes in edge profile. It also reduces the tendency by drivers to cut the corners of small radius curves. If the curve radii are large enough, sight distances will be greatly improved and may allow for safe overtaking.

Long sections of small radius curves should be avoided where possible since drivers travelling at speeds higher than the design speeds may find it difficult to remain in the carriageway. Curve widening could solve this problem although this would mean added costs.

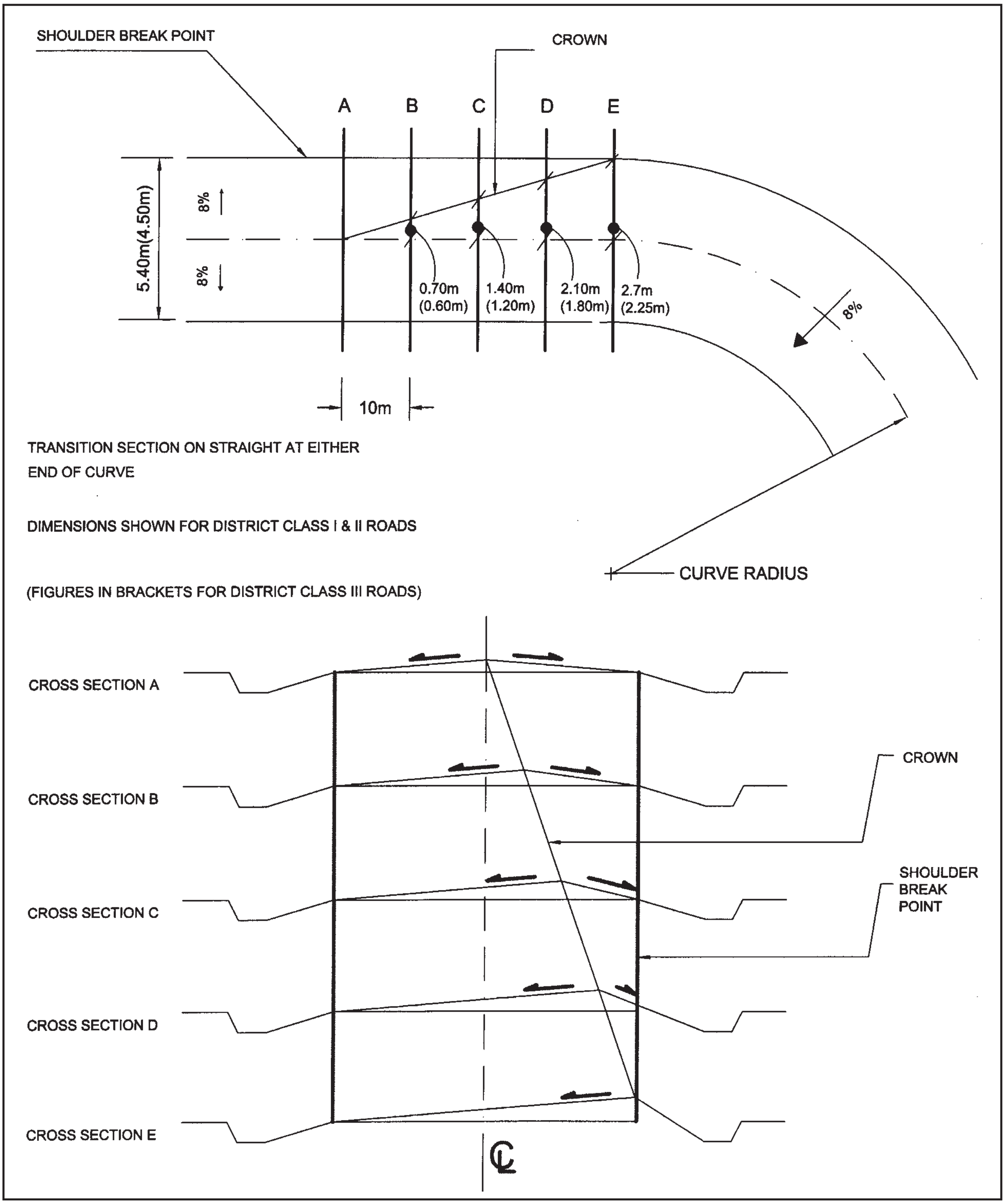
Abrupt changes in direction from successive curves should be avoided where possible. Successive curves in the same direction should also be separated by an appropriate straight, as drivers are unlikely to anticipate what may be an abrupt change in radial acceleration.

Super elevation

The normal cross fall on a road will result in vehicles on the outside lane of a horizontal curve needing to develop high levels of frictional force to resist sliding; the amount of increase being dependent on speed, curve radius and cross fall. Where the horizontal curve has a radius of less than the values given in the table under **Table 2-B2** at the end of this section, super elevation should be applied.

Transition sections are required both before and after the curve over which the super elevation is introduced and withdrawn. These sections are normally 40 metres long and the super elevation is phased in and out as shown in **Figure 2-B2**.

FIGURE 2 - B2: APPLICATION OF SUPER ELEVATION



Curve widening

Widening of the carriageway will be essential on horizontal curves to allow for the swept paths of trucks and to allow drivers to manoeuver when approaching other vehicles. The required amount of widening is dependent on the characteristics of the vehicles using the road, the radius and length of the curve, and lateral clearances.

The following levels of widening are recommended:

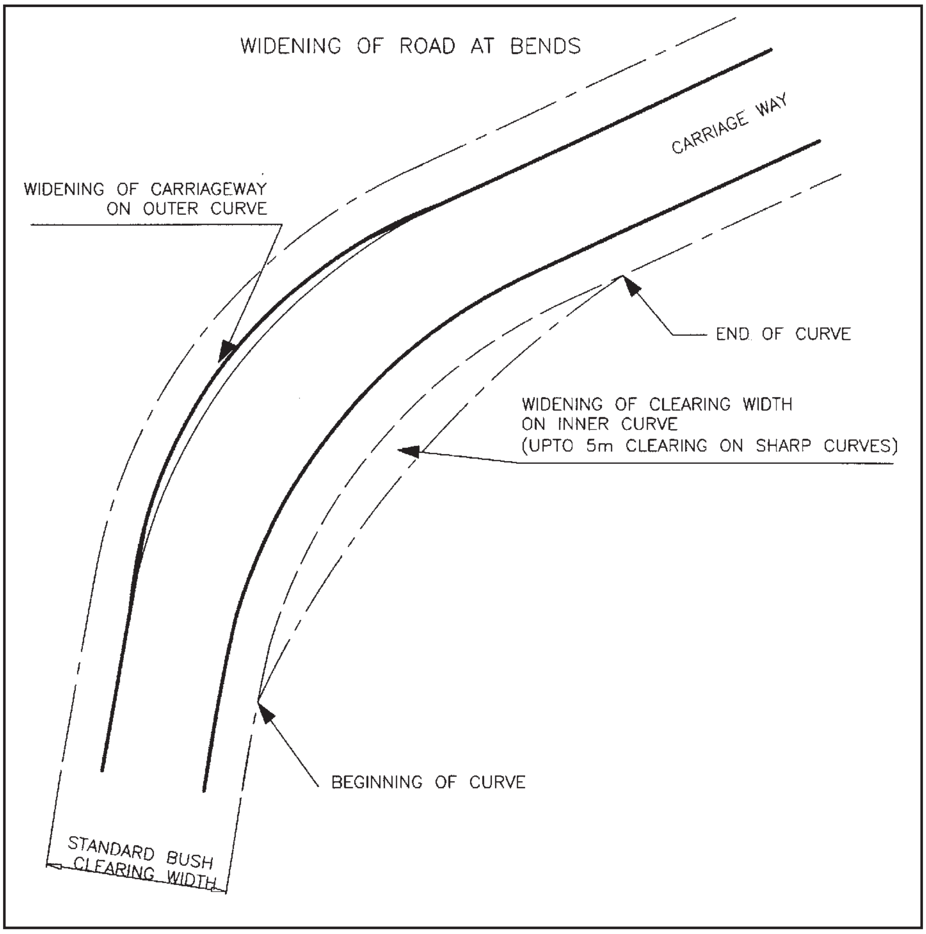
TABLE 1 - B2: CURVE WIDENING: RELATIONSHIP BETWEEN CURVE RADIUS AND INCREASE IN WIDTH

Curve radius (m)	20	30	40	60
Increase in width (m)	1.50	1.00	0.75	0.50

The above values are guidelines only and there will be many situations where widening will be neither necessary nor cost-effective.

Widening should be applied on the inside of a curve and be gradually introduced over the length of the transition.

FIGURE 3 - B2: CURVE WIDENING



Radius of curvature

In alignment, the use of the sharpest curve permitted for the particular design speed being used should be avoided wherever possible. Generally, the flattest curve practical should be used.

Sharp curves should not be used at the end of long straights (i.e. straights more than 500 metres long).

Abrupt changes from flat curvature to sharp curvature should be avoided. Change from flat curvature to sharp curvature should be approached by compatible curves. Compatible curves are achieved when the radius of curvature of one curve is not more than 50% greater and/or not more than 33.3% less than a curve immediately adjacent to it.

VERTICAL ALIGNMENT

The vertical alignment has a great influence on vehicle speeds, economy of transport, road safety and construction costs. However, on roads with low traffic volume road user savings are less significant; the alignment that gives the lowest construction costs should generally be adopted.

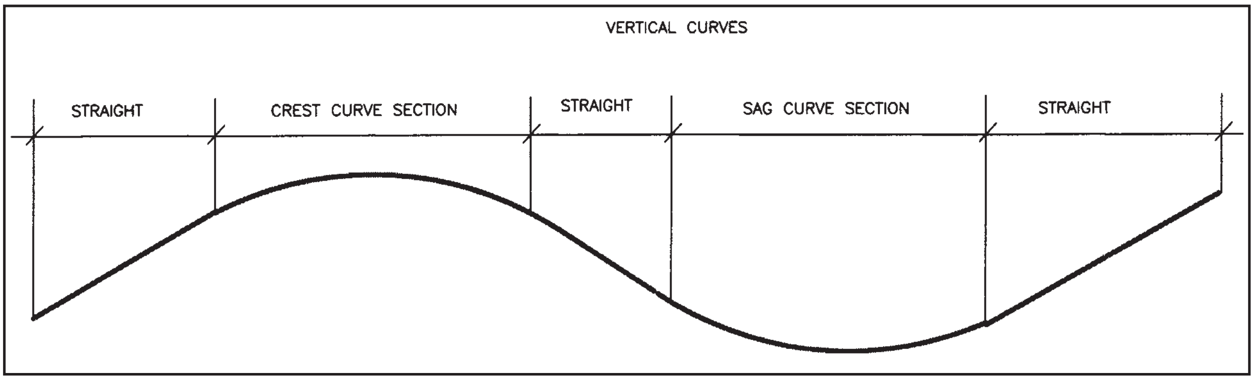
Gradients

A desirable minimum gradient is required for adequate drainage and the recommended minimum gradient for any situation shall be 2%. Most loaded vehicles would be unable to safely negotiate steeper gradients than those given in the **Table 2-B2** for a gravel surface. If the criteria in the **Table 2-B2** cannot be achieved, the District Engineer should consider options such as hairpin bends, alternative surfacing, etc. Warning signs should be erected in advance of any potential hazards. Gradients can be checked simply using an ordinary level instrument or line level and string.

Vertical curves

Vertical curves are applied to effect the transition between straight gradients. There are two types of vertical curves, namely **crest** vertical curves and **sag** vertical curves.

FIGURE 4 - B2: VERTICAL CURVES



Crest Vertical Curves

The minimum lengths of crest vertical curves should be designed to provide sufficient sight distance during daylight conditions. Longer lengths would be needed to meet the same visibility requirements at night on unlit roads. Even on a level road, low meeting beam headlight illumination may not even show up small objects at the design stopping sight distances. However, it is considered that these longer lengths of curve are not justified as high objects and vehicle tail lights will be illuminated at the required stopping sight distances on crest curves. Vehicles will be identified by the approaching illumination and drivers should be more alert at night and/or be travelling at reduced speed.

Sag Vertical Curves

It is assumed that adequate sight distance will be available on sag curves in daylight. However, at night, the distance illuminated by the headlamp beams limits visibility and minimum sag curve lengths for this condition are slightly different from those for crest curves. The use of the formulae given on the next page for sag curves can lead to requirements for unrealistically long vertical curves as, especially at higher speeds, sight distances may be in excess of the effective range of the headlamp beam, particularly when low meeting beams are used. Thus, the only likely situation when these equations should be considered for use is on the approaches to drifts and other similar locations where flowing or standing water may be present on the road surface. In any case, some of these structures occur on low speed roads where headlamp illumination is more likely to reach the full sight distances.

It is recommended that, for most situations, sag curves be designed using the driver comfort criterion of vertical acceleration.

K values for vertical curves (radii of curvatures)

The length of a vertical curve is a product of the **K** value and the algebraic difference of the grades as percentages. The **K** values and other geometric design parameters are summarized in **Table 2-B2** below.

The **K** factor for **crest** vertical curves is given by the formula:

$$K = \frac{L}{A} = \frac{S^2}{(372.665)}$$

This applies where S < L

Where L = length of vertical curve

S = sight distance

A = algebraic difference in grade (%)

The **K** factor for **sag** vertical curves for each design speed is defined by the formula:

$$K = \frac{L}{A} = \frac{S^2}{(120 / 3.491S)}$$

This applies where S < L

Where L = length of vertical curve

S = sight distance

A = algebraic difference in grade (%)

TABLE 2 - B2: SUMMARY OF ALIGNMENT STANDARDS FOR DISTRICT ROADS

	Flat terrain			Rolling terrain			Hilly terrain		
	Design speed			Design speed			Design speed		
	50	60	70	40	50	60	30	40	50
Recommended minimum vertical grade (%)	2	2	2	2	2	2	2	2	2
Recommended maximum vertical grade (%)	8	8	7	10	10	8	12	11	10
Maximum grade length at maximum vertical grade (m)	650	800	1000	500	550	600	250	300	500
Absolute maximum vertical grade (%)	10	10	8	12	12	10	15	12	10
Maximum grade length at absolute maximum vertical grade (m)	325	400	500	250	275	300	125	150	250
Design camber (as built) (%)	8	8	8	8	8	8	8	8	8
Minimum curve radius below which super elevation is applied (m)	80	125	190	40	80	125	20	40	80
Minimum curve radii (m)	65	95	145	35	65	95	20	35	65
Safe stopping sight distance (m)	65	85	110	45	65	85	30	45	65
Crest curve K value (for safe stopping sight distance) (m)	12	20	35	8	12	20	5	8	12
Sag K value (for safe stopping sight distance)	12	18	25	8	12	18	5	8	12
Sag K value (for comfort)	2.5	4	5	1.5	2.5	4	1	1.5	2.5

B3 STANDARD CROSS SECTIONS

The application of each cross section is implied by its description. The choice of cross section is made at the planning stage. The choice should be checked on site as rehabilitation work proceeds.

The **Cross Section A** is the standard cross section that shall be used in most situations. The rest of the cross sections (i.e. **B**, **C**, and **D**) shall only be used in few limited specific situations as shown under each district road class.

DISTRICT CLASS I ROADS

The cross sections applicable for District Class I roads are:

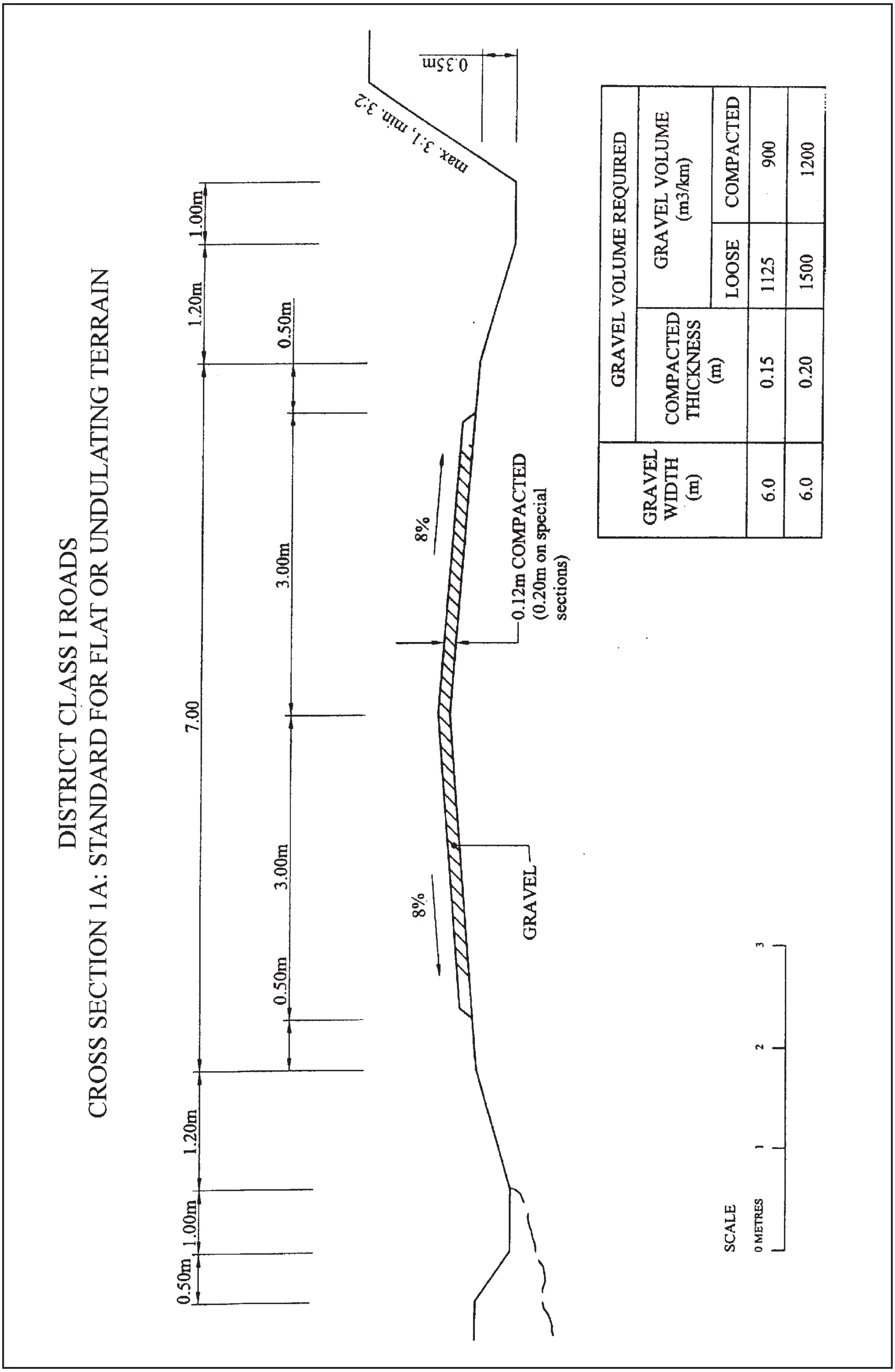
1A: DISTRICT CLASS I ROADS – STANDARD (FOR FLAT OR UNDULATING TERRAIN)

1B: DISTRICT CLASS I ROADS – BLACK COTTON SOIL

1C: DISTRICT CLASS I ROADS – EMBANKMENT

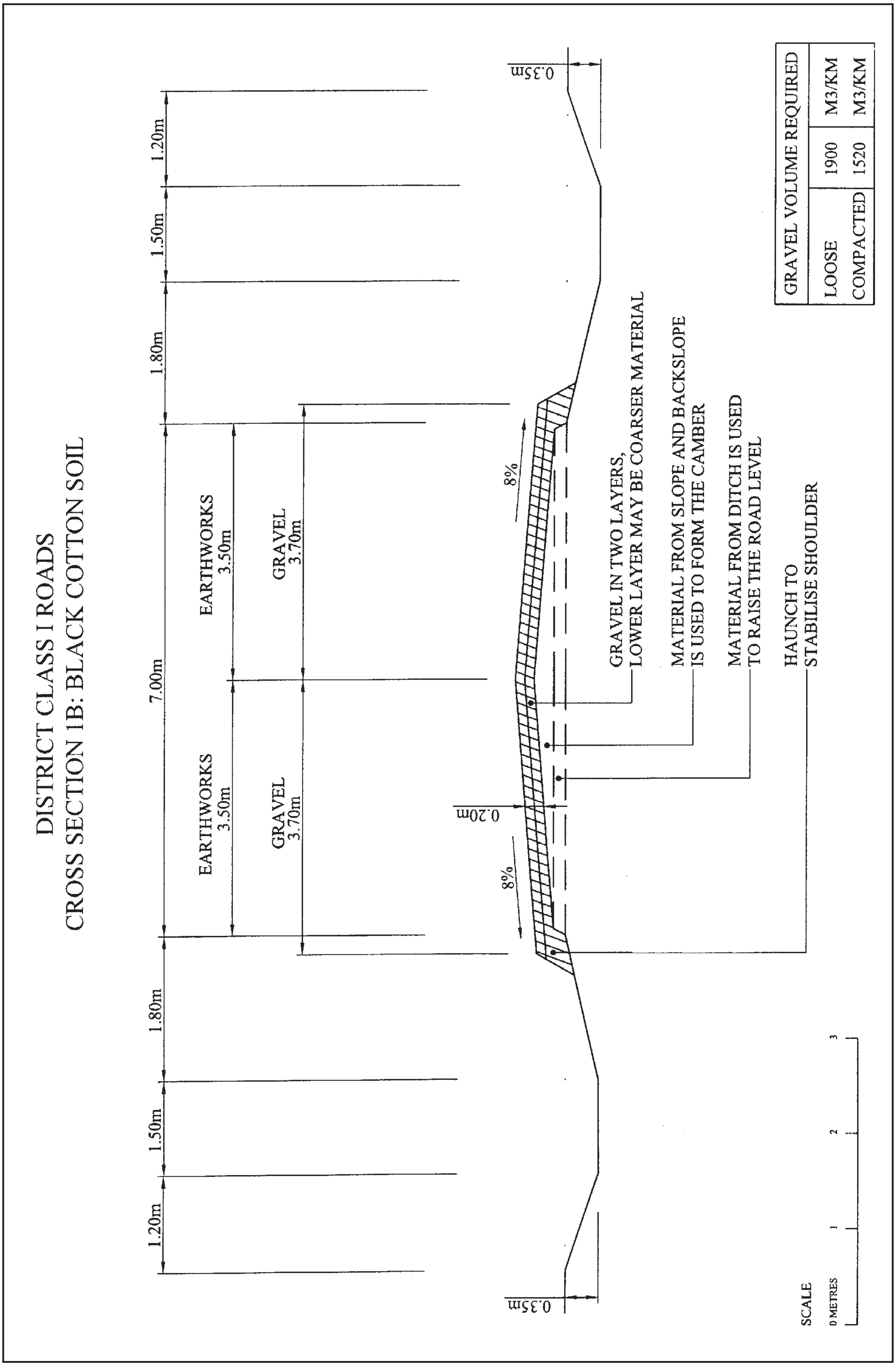
1D: DISTRICT CLASS I ROADS – SUPERELEVATION

FIGURE 1 - B3: DISTRICT CLASS I ROAD - CROSS SECTION 1A FOR STANDARD, FLAT OR UNDULATING TERRAIN



GRAVEL VOLUME REQUIRED			
GRAVEL WIDTH (m)	COMPACTED THICKNESS (m)	GRAVEL VOLUME (m3/km)	
		LOOSE	COMPACTED
6.0	0.15	1125	900
6.0	0.20	1500	1200

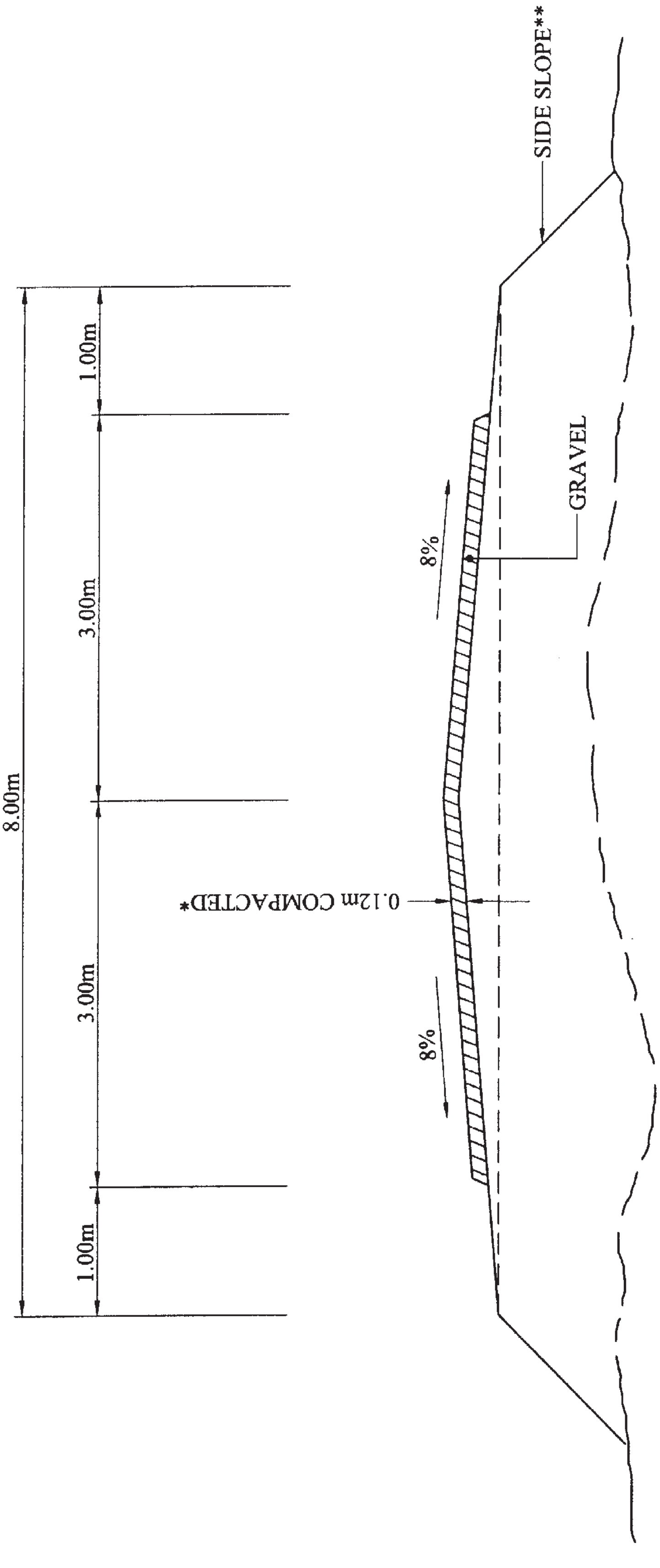
FIGURE 2 - B3: DISTRICT CLASS I ROAD - CROSS SECTION 1B FOR BLACK COTTON SOIL



GRAVEL VOLUME REQUIRED		
LOOSE	1900	M3/KM
COMPACTED	1520	M3/KM

FIGURE 3 - B3: DISTRICT CLASS I ROAD - CROSS SECTION 1C FOR EMBANKMENT

DISTRICT CLASS I ROADS
CROSS SECTION 1C: EMBARKMENT



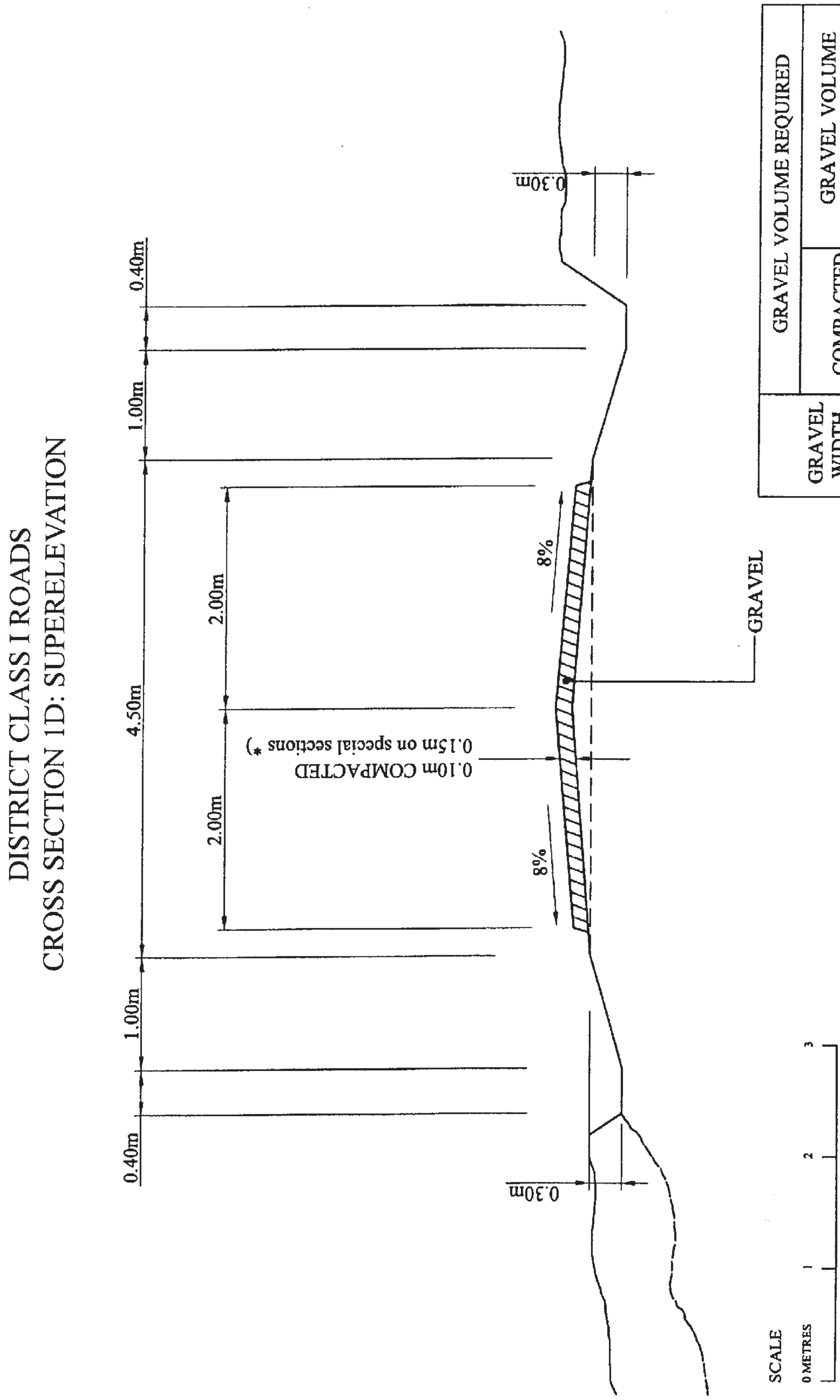
GRAVEL VOLUME REQUIRED		
COMPACTED THICKNESS (m)	GRAVEL VOLUME (m3/km)	
	LOOSE	COMPACTED
0.15	1125	900
0.20	1500	1200

* 0.20m ON BLACK COTTON SOIL
**SIDE SLOPE AS DIRECTED BY THE ENGINEER

NOTE: SIDE SLOPES WILL REQUIRE EROSION PROTECTION MEASURES ON BLACK COTTON SOIL.

SCALE 0 METRES 1 2 3

FIGURE 4 - B3: DISTRICT CLASS I ROAD - CROSS SECTION 1D FOR SUPERELEVATION



GRAVEL VOLUME REQUIRED

GRAVEL WIDTH (m)	COMPACTED THICKNESS (m)	GRAVEL VOLUME (m3/km) LOOSE	GRAVEL VOLUME (m3/km) COMPACTED
4.0	0.10	500	400
	0.15	760	600

* e.g. steep hill sections
For traffic more than 15 vpd, use Spine Road cross sections

DISTRICT CLASS II ROADS

The cross sections applicable for District Class II roads are:

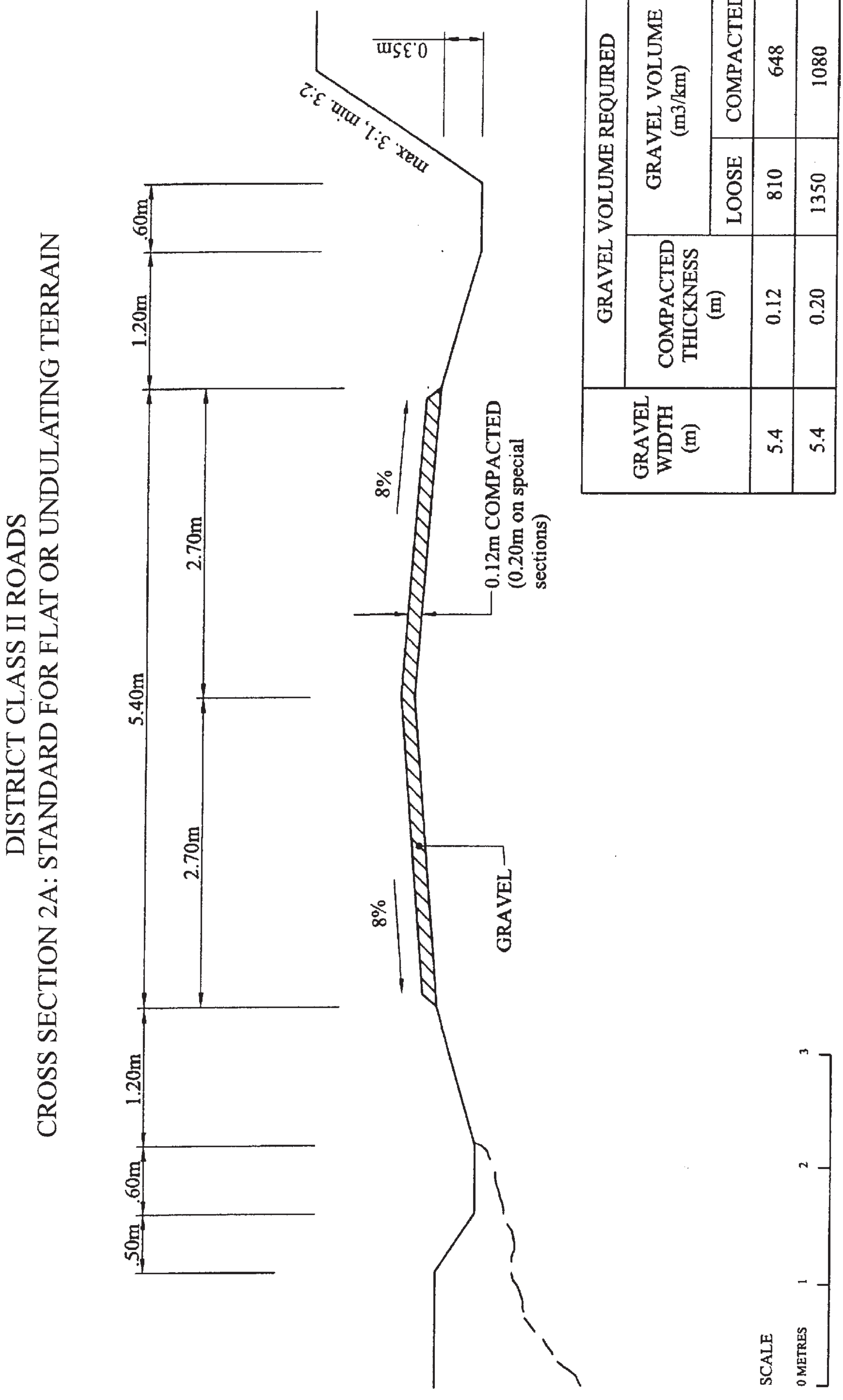
2A: DISTRICT CLASS II ROADS – STANDARD (FOR FLAT OR UNDULATING TERRAIN)

2B: DISTRICT CLASS II ROADS – BLACK COTTON SOIL

2C: DISTRICT CLASS II ROADS – EMBANKMENT

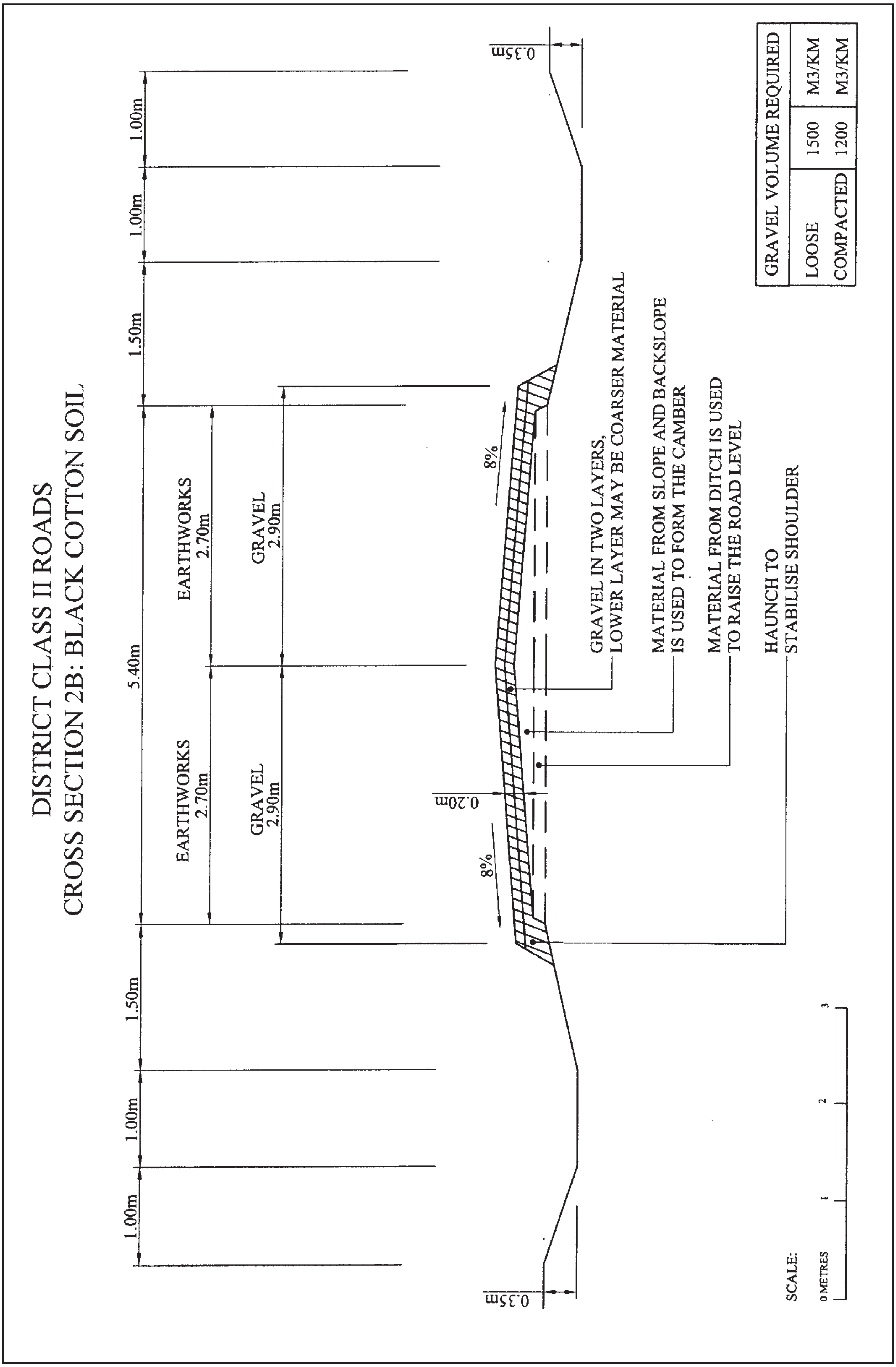
2D: DISTRICT CLASS II ROADS – SUPERELEVATION

FIGURE 5 - B3: DISTRICT CLASS II ROAD - CROSS SECTION 2A FOR STANDARD FLAT OR UNDULATING TERRAIN



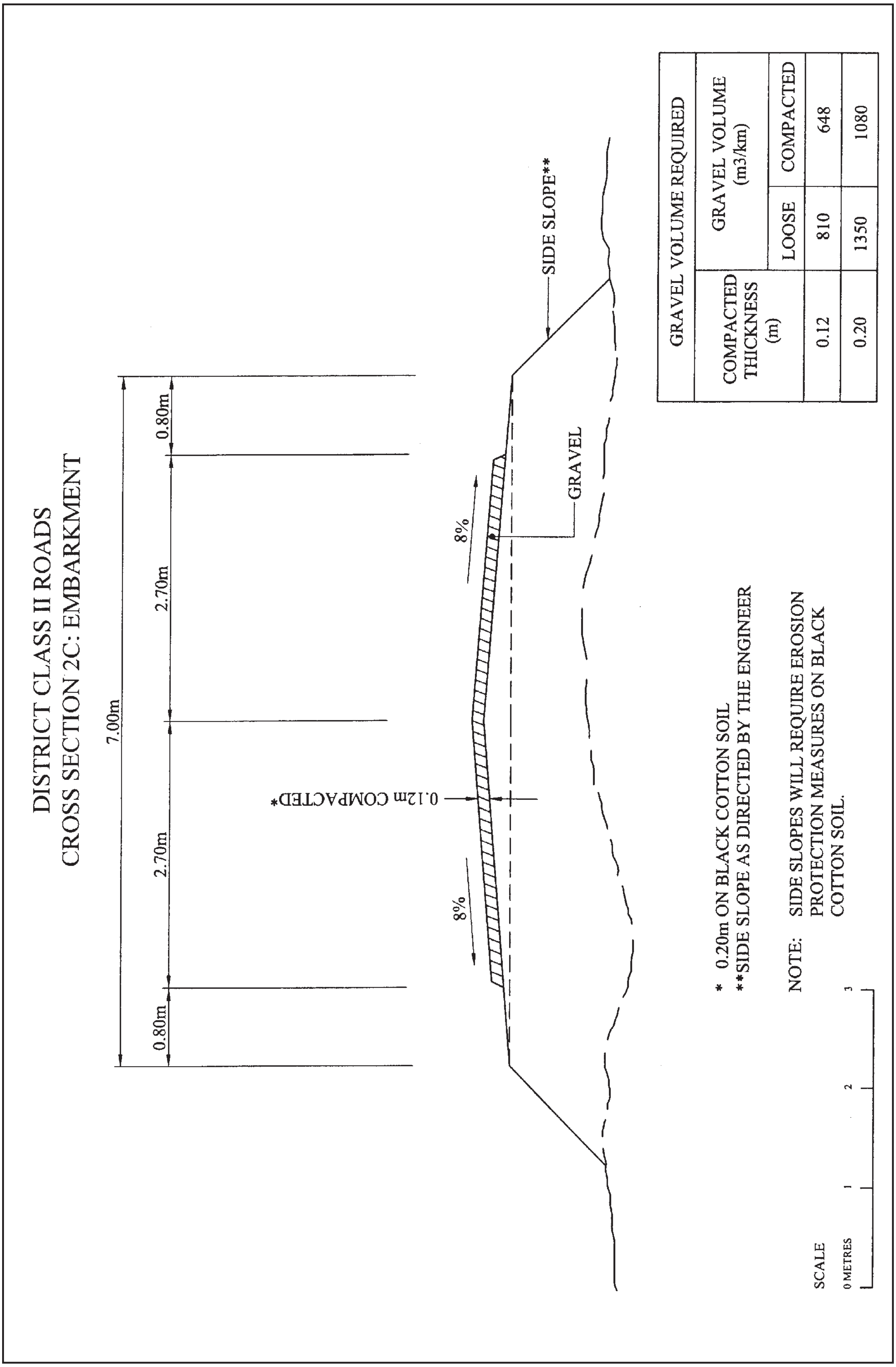
GRAVEL WIDTH (m)	GRAVEL VOLUME REQUIRED		
	COMPACTED THICKNESS (m)	GRAVEL VOLUME (m3/km)	
		LOOSE	COMPACTED
5.4	0.12	810	648
5.4	0.20	1350	1080

FIGURE 6 - B3: DISTRICT CLASS II ROAD - CROSS SECTION 2B FOR BLACK COTTON SOIL



Standard Design B
Road X-Sections 3

FIGURE 7 - B3: DISTRICT CLASS II ROAD - CROSS SECTION 2C FOR EMBANKMENT



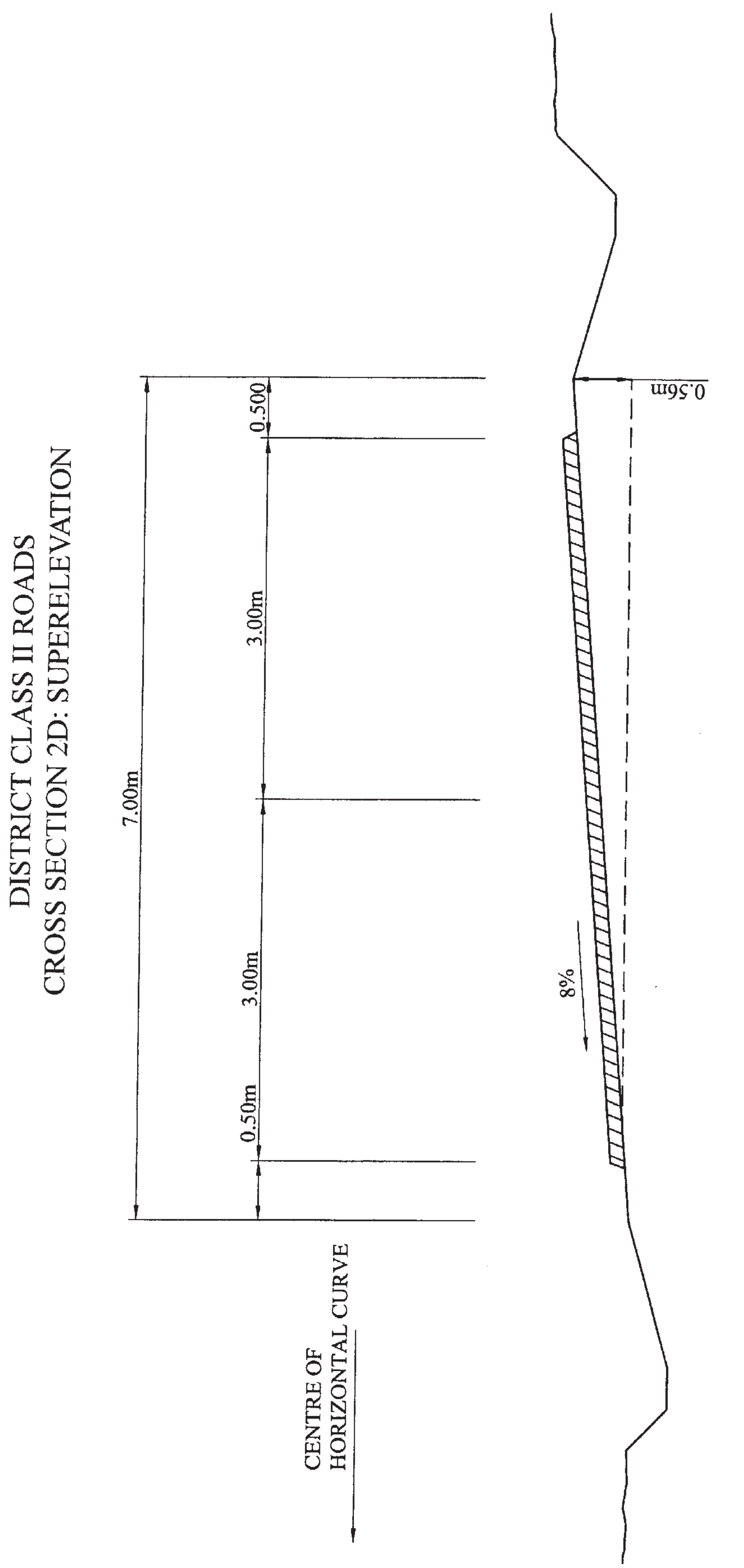
GRAVEL VOLUME REQUIRED

COMPACTED THICKNESS (m)	GRAVEL VOLUME (m3/km) LOOSE	COMPACTED
0.12	810	648
0.20	1350	1080

Standard Design **B**
Road X-Sections **3**

FIGURE 8 - B3: DISTRICT CLASS II ROAD - CROSS SECTION 2D FOR SUPERELEVATION

GRAVEL VOLUME REQUIRED			
GRAVEL WIDTH (m)	COMPACTED THICKNESS (m)	GRAVEL VOLUME (m3/km)	
		LOOSE	COMPACTED
6.0	0.15	1080	900
6.0	0.20	1440	1200



DISTRICT CLASS III ROADS

The cross sections applicable for District Class III roads are:

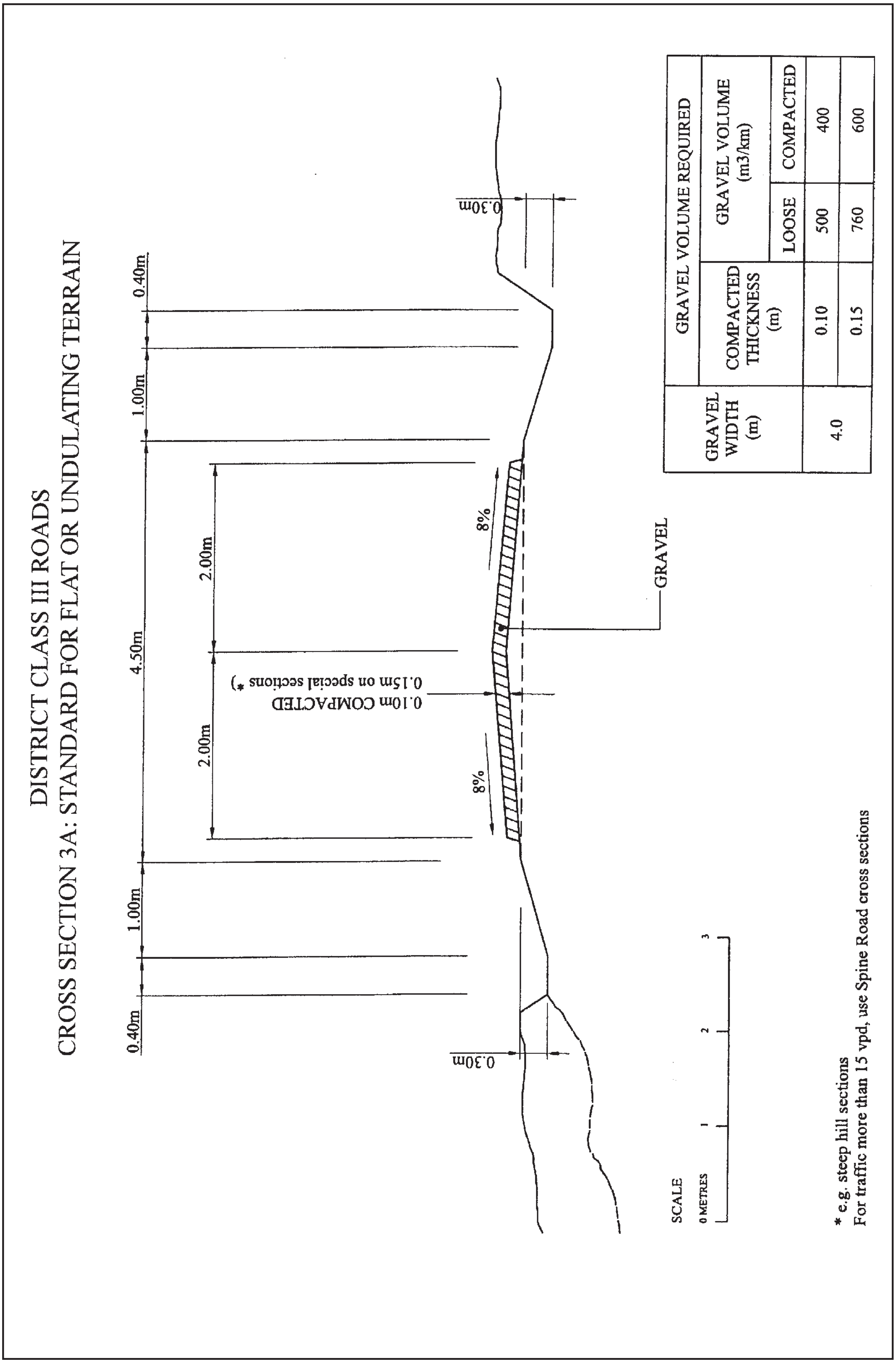
3A: DISTRICT CLASS III ROADS – STANDARD (FOR FLAT OR UNDULATING TERRAIN)

3B: DISTRICT CLASS III ROADS – BLACK COTTON SOIL

3C: DISTRICT CLASS III ROADS – EMBANKMENT

3D: DISTRICT CLASS III ROADS – SUPERELEVATION

FIGURE 9 - B3: DISTRICT CLASS III ROAD - CROSS SECTION 3A FOR STANDARD FLAT OR UNDULATING TERRAIN



GRAVEL VOLUME REQUIRED

GRAVEL WIDTH (m)	COMPACTED THICKNESS (m)	GRAVEL VOLUME (m3/km) LOOSE	GRAVEL VOLUME (m3/km) COMPACTED
4.0	0.10	500	400
	0.15	760	600

FIGURE 101 - B3: DISTRICT CLASS III ROAD - CROSS SECTION 3B FOR BLACK COTTON SOIL

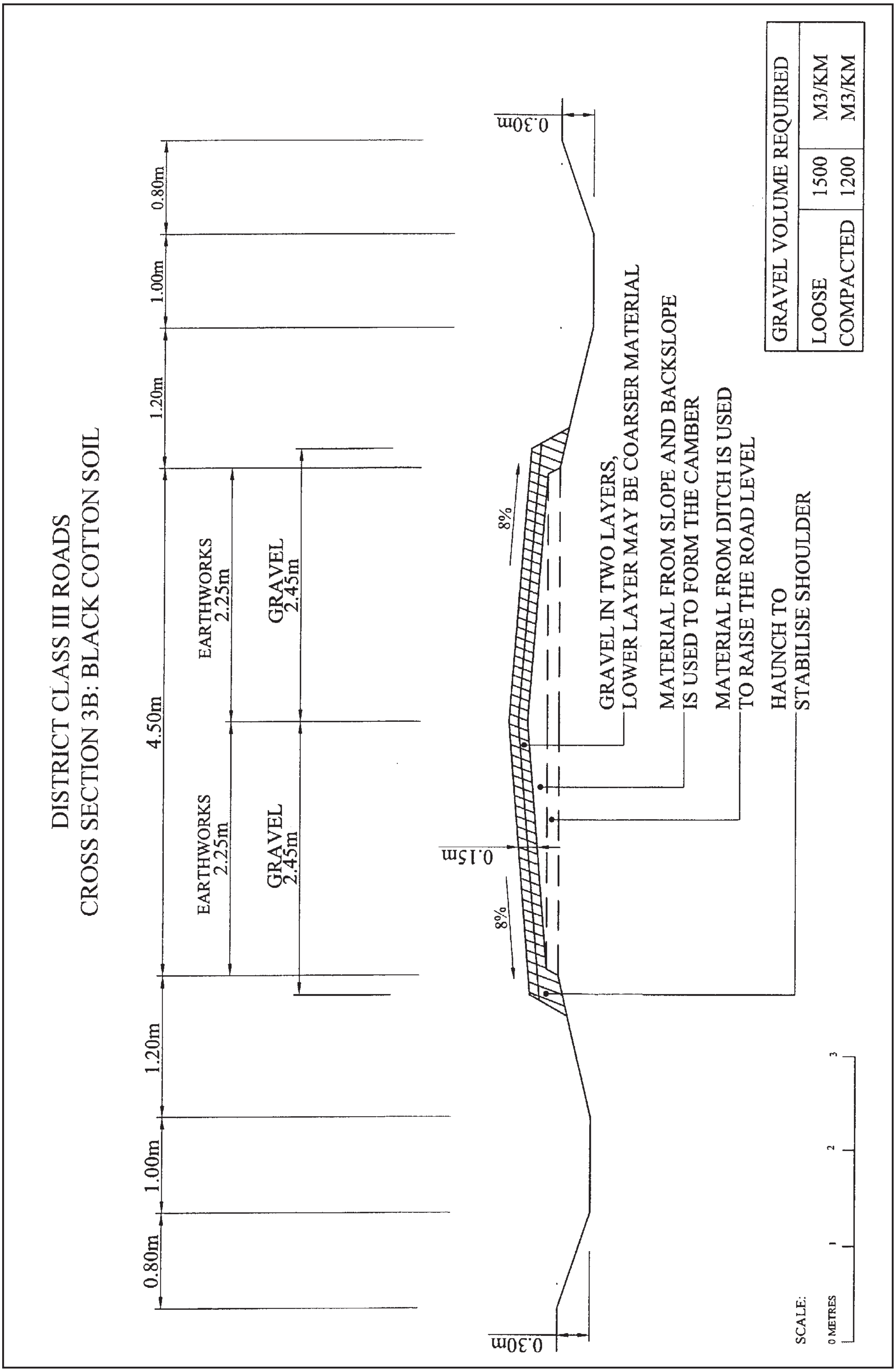
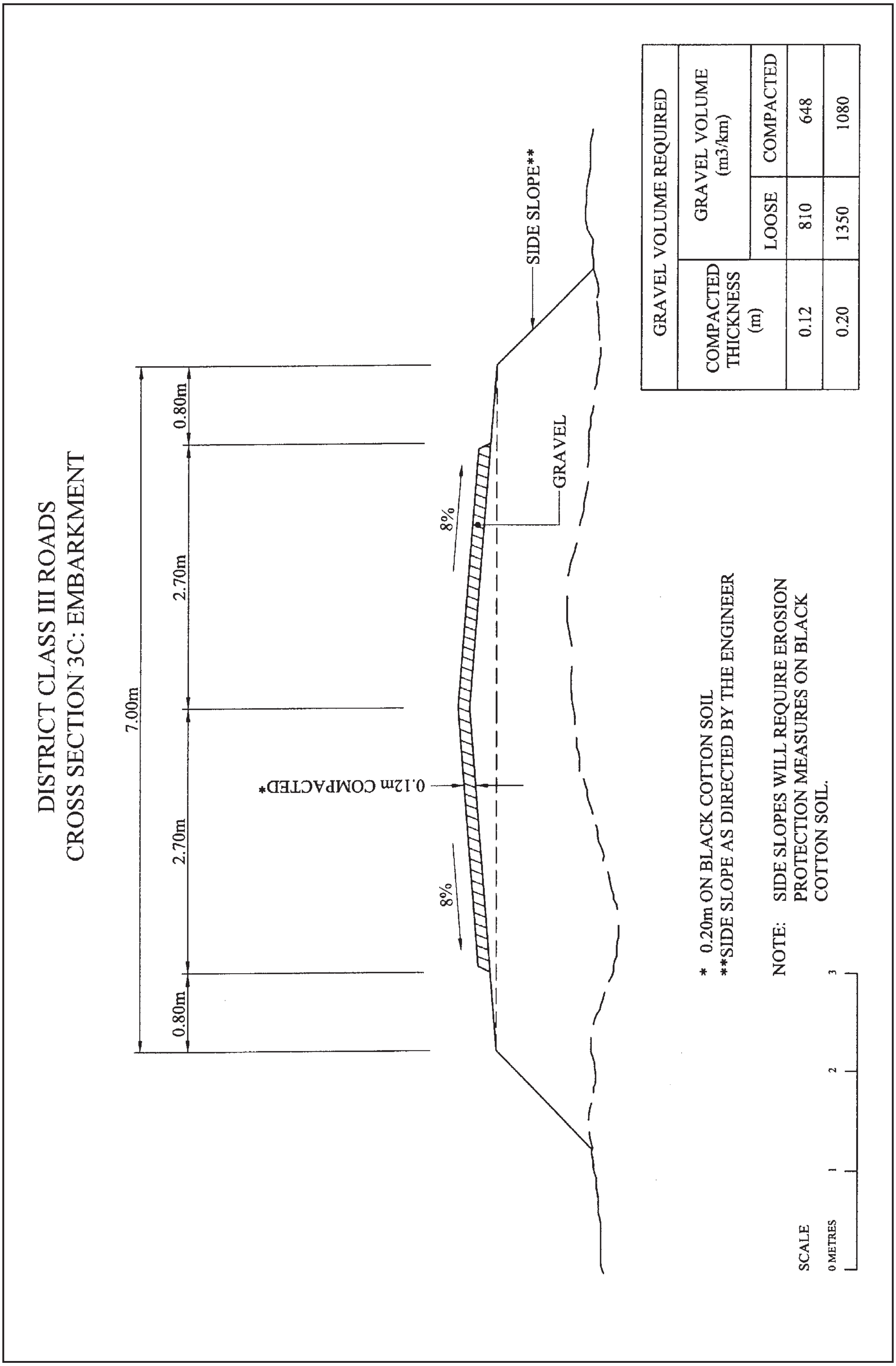
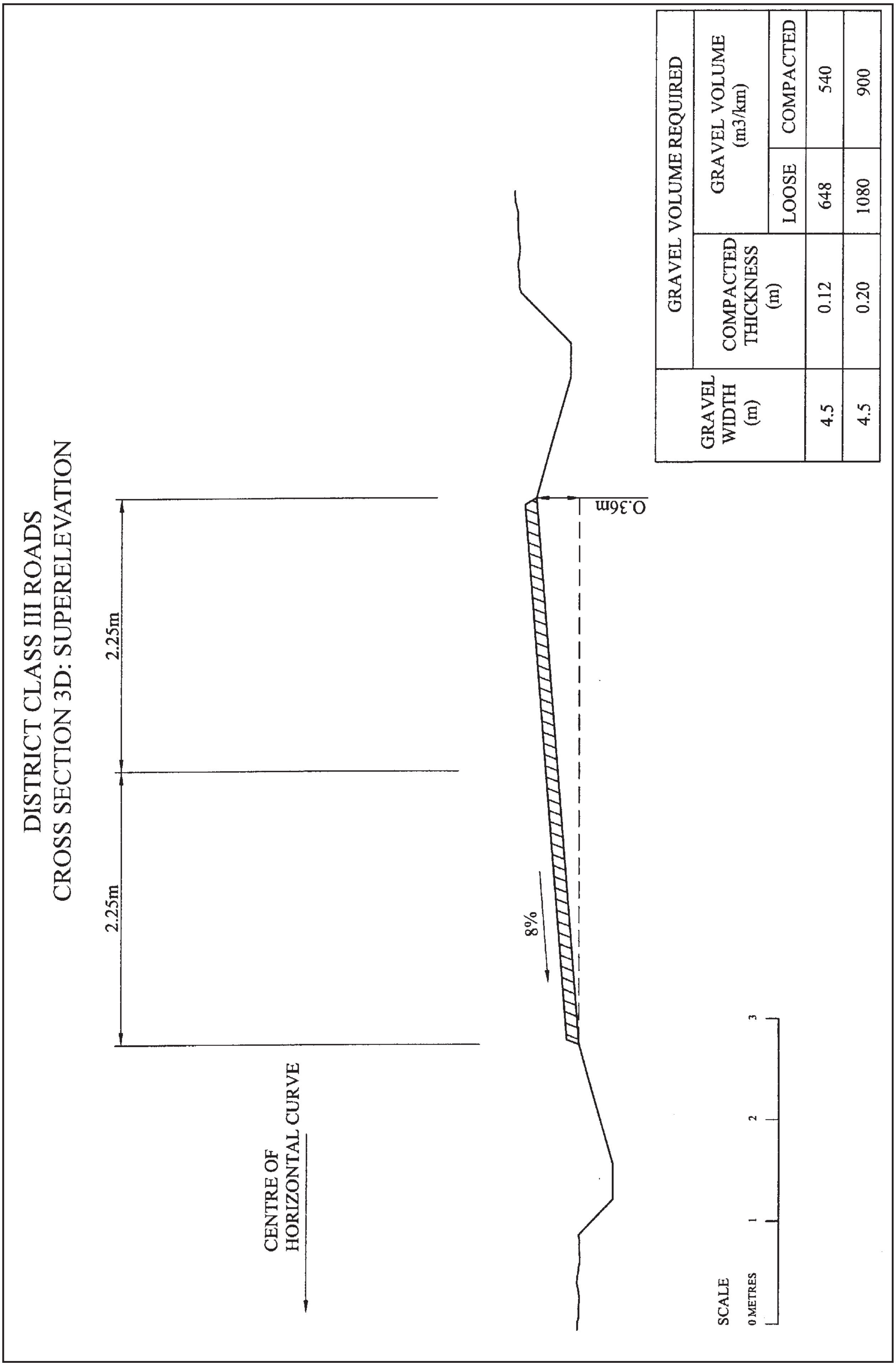


FIGURE 11 - B3: DISTRICT CLASS III ROAD - CROSS SECTION 3C FOR EMBANKMENT



GRAVEL VOLUME REQUIRED		
COMPACTED THICKNESS (m)	GRAVEL VOLUME (m3/km)	
	LOOSE	COMPACTED
0.12	810	648
0.20	1350	1080

FIGURE 12 - B3: DISTRICT CLASS III ROAD - CROSS SECTION 3D FOR SUPEREVELATION



GRAVEL VOLUME REQUIRED

GRAVEL WIDTH (m)	COMPACTED THICKNESS (m)	GRAVEL VOLUME (m3/km)	
		LOOSE	COMPACTED
4.5	0.12	648	540
4.5	0.20	1080	900

B4 JUNCTION LAYOUT

Junctions or intersections are necessary to allow vehicles to access to and exit from the road. Access points should not be located at following positions:

- where earthworks are heavy
- near bridges
- on small radius curves
- on steep gradients

The provision of safety standards is either expensive or impossible to obtain at such positions. Adequate visibility under night driving shall be considered when planning junctions. Entry and exit radii shall be between 8 and 12 metres. However, entry radii from Community Access Roads can be reduced to as little as 2 metres.

The alignment of the district road shall run smoothly into the major road cross-fall. Cross-falls of the **bellmouth** formed by the feeder road junction are to be provided to ensure that surface water is shed effectively towards the side drains.

GEOMETRY

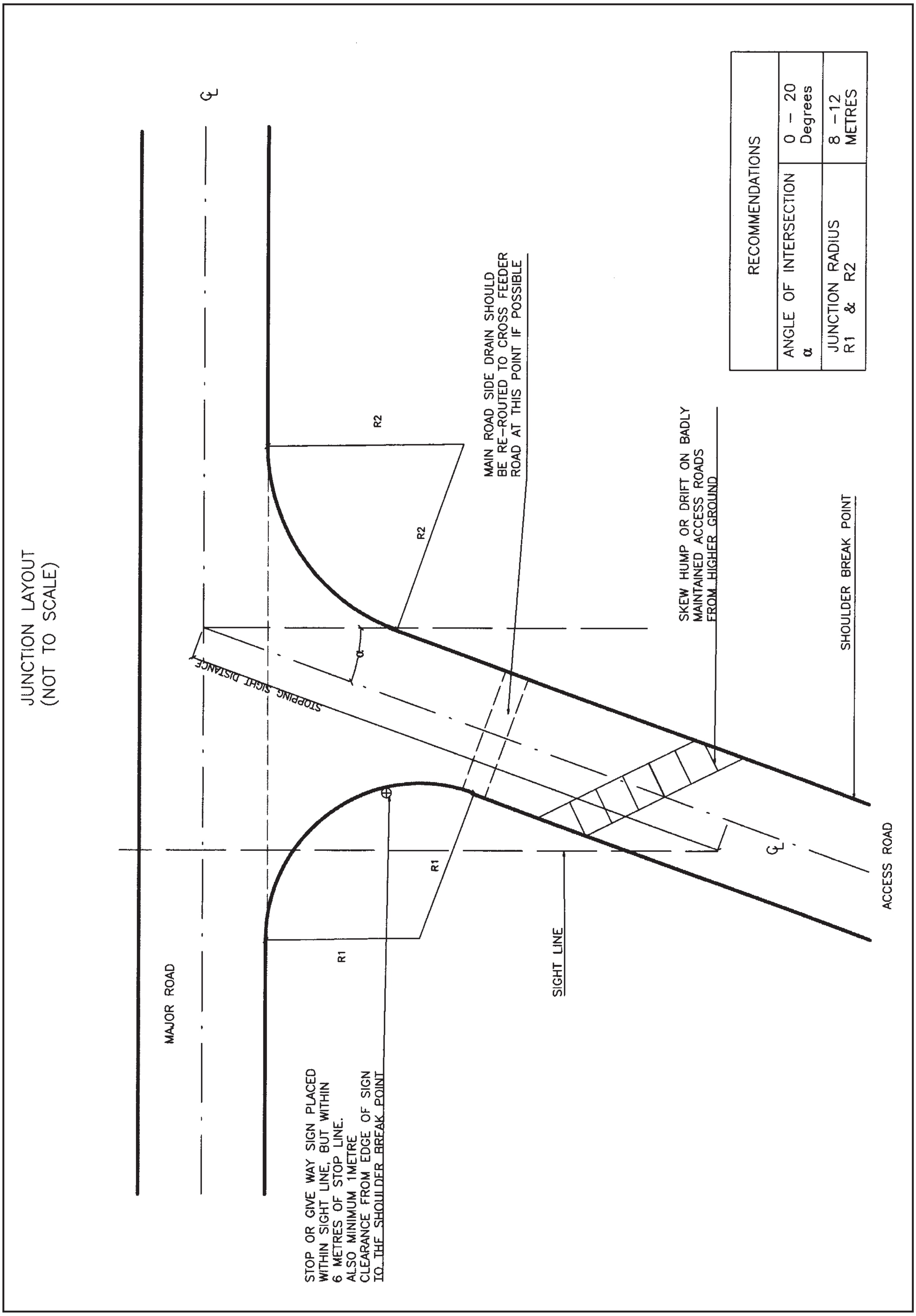
Access roads joining a major road shall be re-aligned such that the angle of intersection is 90^{o} (i.e. the centre lines of the two roads form a right angle). Where this is difficult to achieve the angle of intersection may be decreased up to a minimum of 20^{o}.

DRAINAGE

The side drain of the major road should be rerouted to cross the access road at its narrowest point to avoid unnecessarily long culverts which would be expensive to construct and difficult to maintain. Depending on the type and the function of the access road, the access culvert can be substituted by a drift.

Small access roads are often badly maintained and, in some cases, without any proper drainage system. If such access roads come in from higher terrain, they will spill out all the run-off into the junction during the rains. This may result in gravel wash-away or severe erosion on the major road. Care must be taken to prevent this from happening by constructing a gentle and skew hump or a drift across the access road and reshape the road to include side drains and a camber. This will result in water being shed into the side drains.

FIGURE 1 - B4: JUNCTIONAL LAYOUT



B5 DRAINAGE STANDARDS

Roads that become impassable usually do so because of poor drainage.

The drainage system is one of the most important features of the road. It consists of side drains, mitre (or turn out) drains, cross drains, catchwater drains and scour checks. Cross drains include culverts, drifts (fords), vented drifts (vented fords or causeways) and bridges.

It is essential that adequate provision be made throughout the road to efficiently collect and discharge rain water falling onto the area of the road. Rainwater should be discharged as frequently as possible to minimize erosion damage to the road, the drainage system and to the adjacent land. Discharge should be “little and often” at suitable interval.

DRAINS

Side drains

The inverts of the side drains shall not be less than 300mm below the **shoulder break point**. The invert width shall not be less than 400mm. All cuttings shall be provided with a side drain on both sides of the roadway. On fill sections where the shoulder break point is more than 300mm higher than the natural ground level, no side drains shall be provided on the side of the roadway that this situation occurs (See **Section B3**).

Mitre drains

As a general rule, mitre drains should be provided every 20 metres where possible. This ensures that the quantity of water being discharged at each mitre drain is small, and does not cause erosion damage to the drainage system or on the adjoining land. Where it is difficult to place mitre drains frequently, attention should be paid to providing at least one drainage-outlet for a side drain (using a mitre drain or a cross drain) every 100 metres. The maximum distance between the side drain outlets (by cross drain or mitre drain) should normally be 200 metres. If it is not possible to meet this requirement, erosion control measures, such as ditch lining, should be considered.

TABLE 1 - B5: MITRE DRAIN SPACING

Longitudinal road gradient (%)	Maximum mitre drain interval (m)
1 ~ 2	50
3 ~ 4	200
5	180
6	160
7 ~ 8	120
9 ~ 10	80
11 ~ 12	40

Over the first 5 metres of the mitre drain, an invert slope of 2 ~ 3% should be aimed for and thereafter, an invert slope not exceeding 2% shall be adopted. These invert slopes ensure minimum erosion. The last 5 metres should, ideally, have a slope of 0%. However, a general slope of 2 ~ 3% throughout the entire length of the mitre drain is also acceptable.

The angle at which the mitre drain turns out from the side drain shall be between 30° and 45°.

Mitre banks (material in the side drain to direct water into the mitre drain) shall be constructed to the same height as the shoulder break point and, where dictated by the longitudinal gradient of the side drain, the upstream face shall be protected from scour by planting grass or stone pitching. Side slopes of banks and drains shall be 1 : 4.

Catchwater drains

On side cuts and in full cuts, catchwater drains are required to intercept run-off water from big catchment areas above the roadway, which would otherwise, unnecessarily overload and silt the side drains. Catchwater drains also assist in protecting steep cut slopes from severe erosion from the run-off water above the road. Catchwater drains shall be provided where excessive run-off is expected above the roadway.

CROSS DRAINANGE

Cross drainage is any structure that allows water to safely cross the road. The purpose of cross drainage is to periodically remove the volume of water carried by the side drains in order that the drains do not overtop and cause damage to both the ditch cross section (by scouring) and the roadway, and allow the water carried in natural watercourses to cross the roadway safely and efficiently. The most common cross drainage structures include culverts, drifts, vented drifts and small bridges. The intervals required for standard cross drainage structures are detailed in **Table 2-B5** below.

TABLE 2 - B5: LATERAL SPACING INTERVAL BETWEEN STANDARD CROSS DRAINAGE STRUCTURES

Longitudinal gradient of roadway centre line (%)	Recommended interval between cross drainage structures (m)
2	200
3 ~ 4	150
5	135
6	120
7 ~ 8	100
9 ~ 10	80
11 ~ 12	60

Culverts

Concrete ring culverts or Armco pipe culverts will be provided to allow water to cross from one side of the road to the other. Due to maintenance problems with smaller sizes, the recommended minimum ring size will be 600 mm in diameter.

For safety and riding comfort reasons, ramps over culvert crossings should be avoided. (If for some reason, it is unavoidable, an approach ramp of not less than 5 metres with maximum longitudinal gradient of 5% on each side of the culvert should be provided.)

The levels of culverts must be fixed with careful consideration of the existing watercourse levels. The objective should be to make the least change to the vertical and horizontal alignment of the watercourse. The finished road levels should then be determined in relation to the culvert. Minimum cover to the pipe culvert should be ¾ of barrel diameter (i.e. 450 mm minimum cover for 600 mm diameter pipe).

Culverts shall have an invert gradient of 2 ~ 5% (ideally 4%) to avoid silting. In extremely flat terrain, invert gradients can be reduced to a minimum of 1.25% to avoid culvert ramps or excessive earthworks for outlet drains. Invert gradients for culverts with drop inlets should be increased by 1% to compensate for loss of velocity.

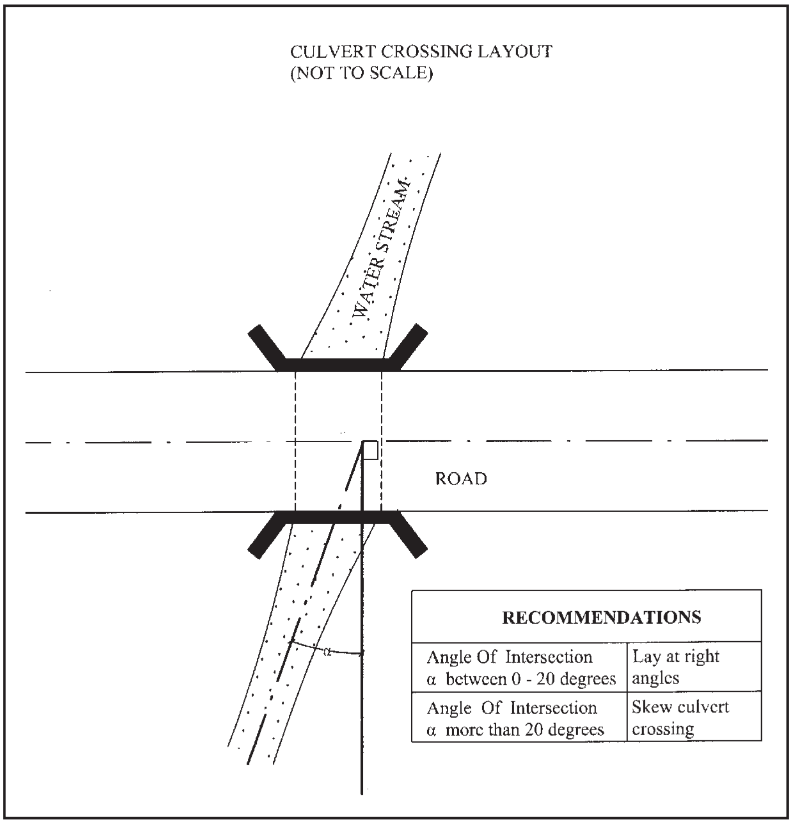
The invert level at the outlet should preferably coincide with natural ground level. If it is above ground level, expensive protection works will be necessary. If the invert level at the outlet is below ground level, then a cost/benefit assessment must be made between excavation of long outlet drains and fill to raise the road level.

Long and flat outlet drains must be avoided because they are expensive to construct and difficult to maintain.

Watercourses meeting the road centreline at an angle less than 20° shall be accommodated by a culvert placed at right angles to the road centreline. The culvert inlet should coincide with the centre of the channel and any modifications to the channel be made downstream of the outlet.

Permanent or seasonal water-courses may need large (900 mm or 1200 mm diameter), multiple culverts or other structure solutions.

FIGURE 1 - B5: CULVERT CROSSING LAYOUT



The basic guidelines for use of culverts on district roads are given below:

- Culverts are generally less expensive than drifts. However, transportation costs to remote areas may make concrete pipes more expensive than drifts.
- Culverts require regular routine maintenance.
- Culverts concentrate the collection and dispersal of water, which implies that serious attention must be paid to inlet and outlet works in order to avoid erosion.
- Culverts provide a more comfortable ride for motorists than drifts.
- Culverts are preferred where cross drainage is at low point where the level of the road is to be raised to improve its longitudinal gradient.

To decide on the choice of structure, the Engineer shall do a cost comparison between the drift and the culvert, taking into account the following:

- Where a culvert discharges into a farmer's field and may increase erosion.
- Where there is rock and excavation is difficult.
- Where soils are such that there is a likelihood of silting.
- Where there is insufficient difference in elevation between the roadway centreline and the side drains and or watercourse invert to allow for the culvert structure, together with any minimum fill over the structure, needed to protect it from traffic loadings.

Drifts

Drifts allow water to safely cross the surface of the roadway. The geometric dimensions of a drift depend on the volume of water expected to cross the road and the geometry of the intended crossing place. The maximum slope of drift approaches shall be 1 **:** 8.

Detailed design drawings are available in the **Volume 4B**. However, the basic guidelines for use of drifts are given below:

- Drifts are surface structures, and thus, easy to maintain
- The volume of excavation required is minimal
- Drift efficiency is directly related to drift invert slope and cross sectional area.
- Due to the discomfort of driving over drifts, too many of them will cause significant delays in journey time due to forced slowing down, thereby restricting speeds close to the design speeds.
- Drifts are likely to cause less erosion than culverts from their discharge.

In general, drifts should be used where the following conditions apply:

- The difference in elevation between the invert of the side drain and/or natural watercourse and the roadway shoulder break point is not greater than 300mm. Where the water level is estimated to exceed 200mm, the approaches must be lengthened to accommodate high water level.
- The subgrade material is rocky and difficult to excavate.
- There is evidence that the natural soils of the side drain and/or watercourse are silt and could lead to the rapid blocking of culverts.
- Where discharge occurs into a farmer's field.
- Where the cost of a culvert of similar capacity is significantly higher than the cost of a drift.

Where possible, drifts should be located to simultaneously discharge water from the side drains and allow water in natural watercourses to safely cross over the roadway.

Drainage at access road junctions

Where motor vehicle access is required to land or properties adjacent to the road, the side drain should be lined with stone pitching, or a small culvert should be provided. More details of drainage lay out at access road junctions are discussed in **Section B4** and shown in the junction layout diagram (see **Figure 1-B4**).

Vented drifts (Vented fords)

These are designed to allow normal flow of a perennial river to pass through openings below the roadway. During the periods of flood the additional flow passes over the structure and over the roadway.

The important considerations that need to be taken into account when designing vented drifts include:

- Only waterways with significant permanent water flows **and** which are subject to periodic flooding should be considered. Often, drifts may be suitable accepting that the crossing site may be impassable for short periods during flooding on a limited number of occasions during a year. The need for a detailed field survey is essential to enable this basic choice (between drift and vented drift).
- Vented drifts **must** always be located on straight sections of the waterway where there are no signs of scour or instability.
- The proposed structure should not interrupt or modify in any way the normal stream flow. The invert level and slope of the vents should be the same as those of the natural stream bed level.
- Where there is evidence of fine silt being carried by the water during the period of normal flow, consideration should be given to the use of wide base arch vents rather than circular pipes which, experience has shown, tend to cause the accumulation of silt at the base of, and between, the pipe vents leading to rapid vent blocking and structural failure.
- During the periods of flood, the vented drift structure will act as an obstacle, causing hydraulic jumps and potentially destructive eddies to form both up and down stream. Thus waterway banks will need to be protected by stone pitching or gabion mattresses and the approaches to the vented drift extended above the maximum-recorded flood level and the cut slopes of these approaches similarly protected.
- Approach roadway longitudinal grades must be carefully designed to obtain a best fit with the vented drift to ensure safety and comfort for the road user. The vented drift must be designed to fully accommodate the flow of water and not to simply satisfy the roadway approach geometry.
- During flooding, it is unlikely that the road user will attempt to cross over the vented drift and the use of many marker posts, which are likely to be damaged by matter carried during floods, are not recommended.

SCOUR CHECKS

Scour checks should be provided in side drains, mitre drains and all outlet drains of gradient greater than 4% according to the guidelines in **Table 3 - B5**:

TABLE 3 - B5: SCOUR CHECK SPACING

GRADIENT OF DRAIN	SCOUR CHECK SPACING
4% or less	not required
5%	20m
6%	15m
7%	10m
8%	7.5m
9%	6m
10%	5m
> 10%	4m
> 12%	line with masonry

SUMMARY SPACINGS FOR MITRE DRAINS, CROSS DRAINS AND SCOURCHECKS

When constructing road the drainage system will function properly only if mitre drains, cross drains and scour check are all constructed. The location and spacing of the necessary drainage facilities depends on the gradient of the road / side drain and can be determined from the table below.

TABLE 4 - B5: SUMMARY SPACING FOR MITRE DRAINS, CROSS DRAINAGE STRUCTURES AND SCOUR CHECKS

Longitudinal road gradient	Maximum mitre drain interval	Recommended interval between cross drainage structures	Scour check spacing
1% ~ 2%	50m	200m	not required
3%	200m	150m	
4%	200m	150m	
5%	180m	135m	20m
6%	160m	120m	15m
7%	120m	100m	10m
8%	120m	100m	7.5m
9%	80m	80m	6m
10%	80m	80m	5m
11%	40m	60m	4m
12%	40m	60m	4m
above 12%	40m	60m	line with masonary

B6 STANDARD ROAD SIGNS

TYPES OF SIGNS

Road signs are grouped into three categories depending on the purpose they serve:

- **Regulatory or mandatory signs**
  These inform road users of the special regulations applying on a section of a road. These signs **MUST** be observed by all motor vehicle traffic using the road section. These signs are usually surmounted by a red circle and a triangle, the latter usually having its apex downwards.

- **Warning signs**
  These warn drivers of potentially hazardous road conditions and allow drivers sufficient time to take the necessary precautionary measures before arriving at the hazardous location. They are recognized by a triangle with its apex upwards.

- **Informative signs**
  These allow drivers to know where they are and which route to take as they drive along. The colour red is rarely, if at all, used with these signs.

In all three categories of signs, there are **permanent traffic signs** and **temporary traffic signs**. Basically, the permanent signs are those that are placed to remain permanently on a road after its construction, whereas the temporary traffic signs are used temporarily on road sections to control traffic where road works are taking place.

The full range of road signs in Uganda is defined in the specifications of the Ministry of Works, Housing and Communications. Some of the common signs used are shown at the end of this section.

INSTALLATION OF ROAD SIGNS

All permanent and temporary road signs should be installed or placed in such a way that they are clearly visible to the motorists. There should further be sufficient space (in time and distance) to allow the driver to respond and take the appropriate action.

Installation of permanent signs

Permanents signs should be positioned in such a way that the, the minimum distance between the position of the sign and the associated hazard, following the direction of travel, is the **safe stopping sight distance** for the design speed of that road section. This is only logical since this minimum distance will ensure that the driver may safely come to a stop if the prevailing circumstances of the hazard so require, e.g. at a narrow crossing where another vehicle is approaching from the opposite direction.

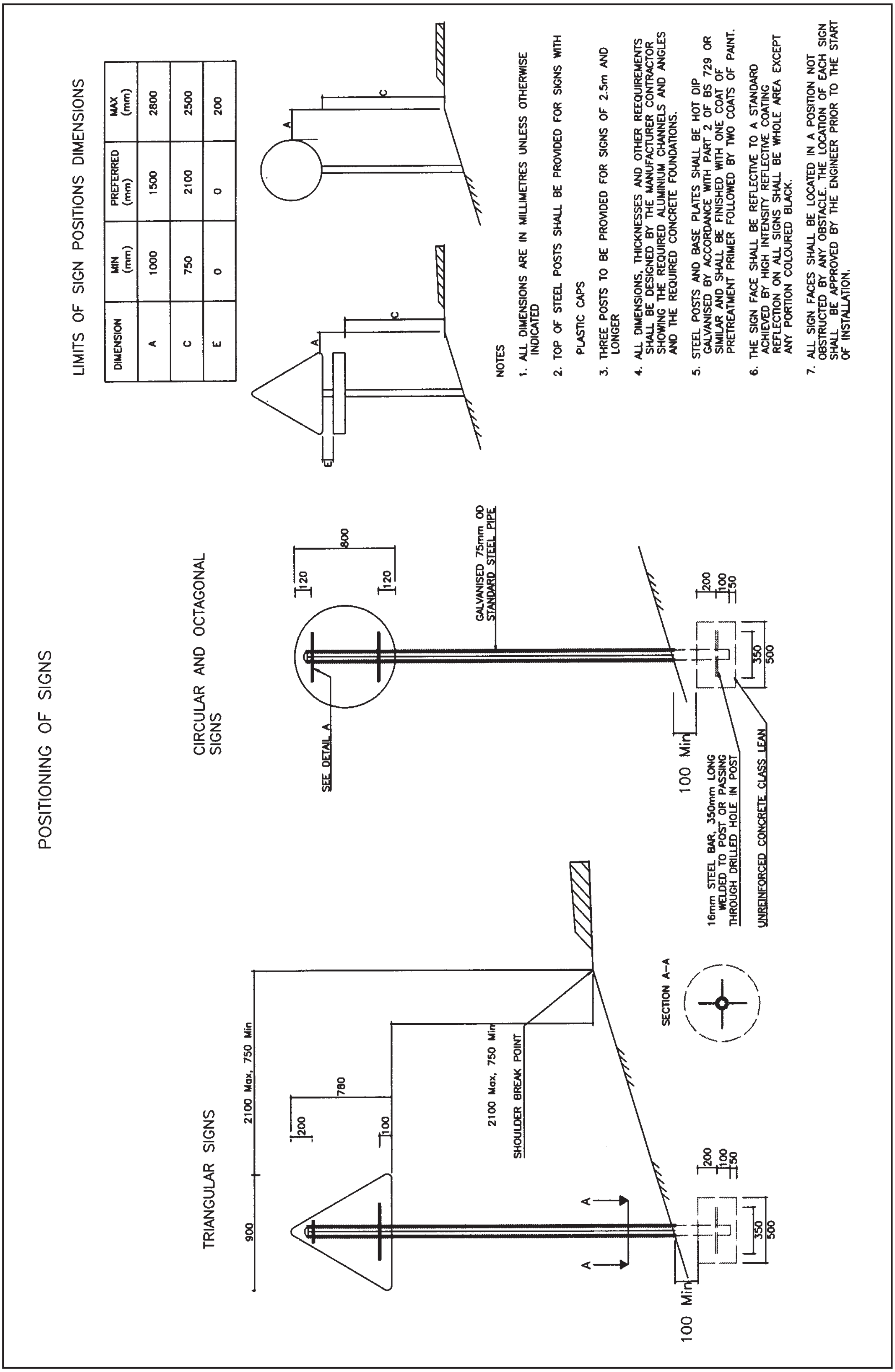
Installation of traffic signs

Temporary traffic signs are used to direct traffic to safely manoeuver their way through or around a roadworks zone. Before work starts and during the works informative and warning signs, barriers and cones must be placed around the work area. Wherever possible, work should be carried out on one side of the road at a time allowing traffic to pass on the other side.

Temporary traffic signs must be positioned and fixed in such a way that the following conditions are satisfied:

- They are clearly visible to the motorists, and provide sufficient reaction time for the motorists
- Those signs that must remain in place throughout the construction period must be securely fixed so that they may not be easily moved about or removed by passers-by.
- The temporary signs must, at all times, be positioned at relevant locations and be moved accordingly as the work progresses. This means the temporary signs must be removed promptly once the works for which they were erected are finished.

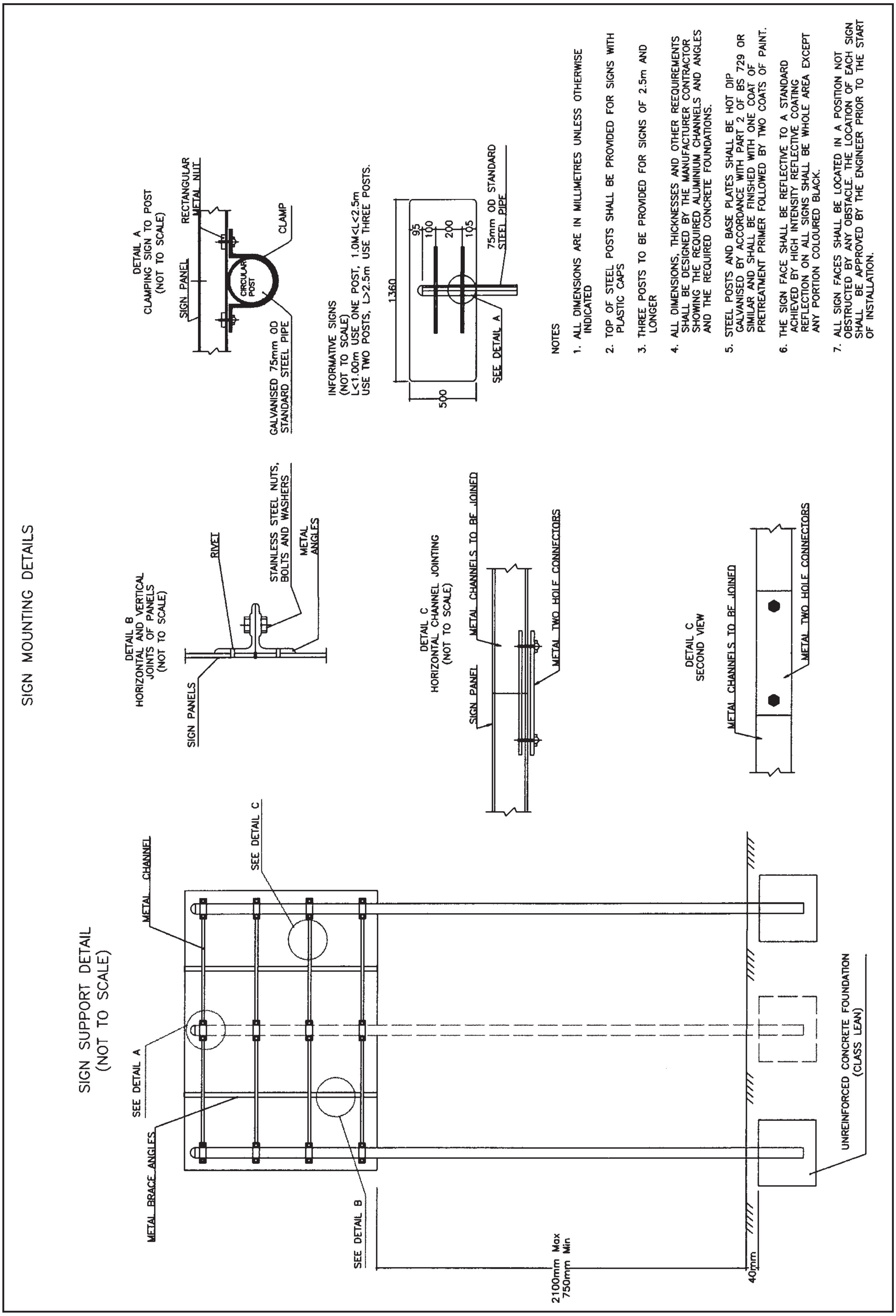
FIGURE 1 - B6: POSITIONING OF SIGNS WITH RESPECT TO THE ROAD CROSS-SECTION



DIMENSION	MIN (mm)	PREFERRED (mm)	MAX (mm)
A	1000	1500	2800
C	750	2100	2500
E	0	0	200

Standard Design B
Standard Road Signs 6

FIGURE 2 - B6: DETAILS OF SIGN MOUNTING



COMMON ROAD TRAFFIC SIGNS

Figure 3 - B6: Regulatory signs

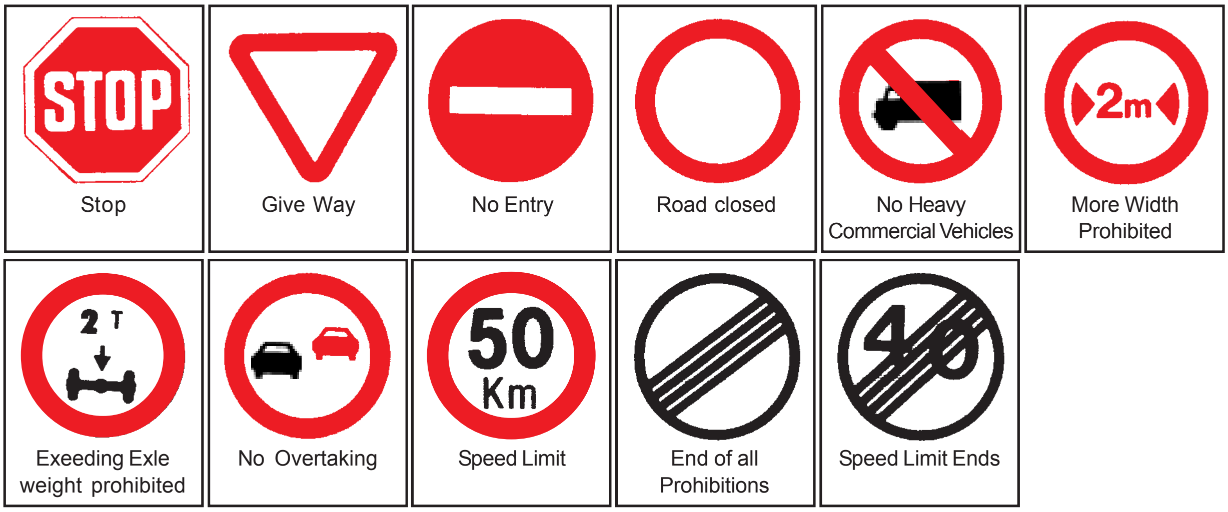
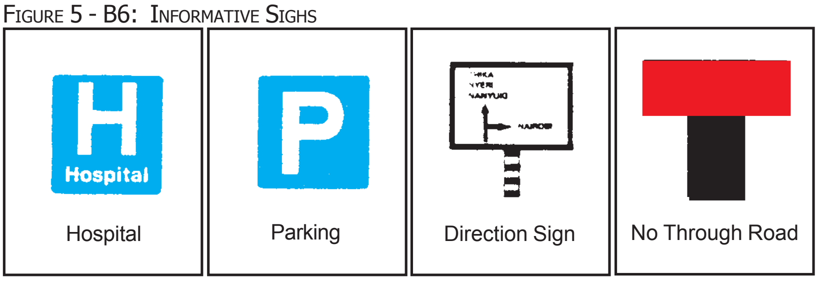


Figure 4 - B6: Warning sighs

Figure 5 - B6: Informative Sighs



Section C

Construction Materials

Section C
Construction Materials

CONSTRUCTION MATERIALS

C1 SOILS

INTRODUCTION

This section presents basic concepts for the investigation, description and classification of soils, and in order to make an assessment of soil strength for use in Engineering.

The physical characteristics of soil materials consist of the particle size distribution, internal friction, voids content, wear resistance and water content determine the engineering properties of soil. These engineering properties of soils greatly depend on the environmental conditions and the level of construction activity to prepare the natural soil.

The Engineer should make the investigation of soils for these properties an integral part of location, design and construction of roads or highways. The soil investigations provide pertinent information about soil and rocks for decision on one or more of the following aspects:

- Selection of road and highway alignment
- Decision on the need for subgrade and embankment foundation treatment
- Investigation of slope stability in cuts and embankments
- Location and design of ditches and culverts
- Selection and design of road pavements
- Location and evaluation of suitable borrow and construction materials
- Design of foundation for bridges and other structures

ENGINEERING CLASSIFICATION OF SOILS

In engineering, soils are classified by gradation properties in the case of granular soils and/or plasticity properties in the case of fine-grained soils.

Soil size and gradation

In this classification scheme soils are defined by their particle sizes and the major range of types comprise (gravels, sands, silts and clays). A summary of various size classifications is shown in **Table 1-C1**.

TABLE 1 - C1 SOIL CLASSIFICATION BY PARTICLE SIZE

Major class	Sub-class	Range of particle size (mm)
Boulders	-	Larger than 200
Cobbles	-	200 - 60
Gravels	Coarse gravel	60 - 20
	Medium gravel	20 - 6
	Fine gravel	6 - 2
Sands	Coarse sand	2 - 0.6
	Medium sand	0.6 - 0.2
	Fine sand	0.2 - 0.06
Silts	Coarse silt	0.06 - 0.02
	Medium silt	0.02 - 0.006
	Fine silt	0.006 - 0.002
Clay	-	Less than 0.002

The distribution of particle size (gradation) is determined by a combination of mechanical (sieve) analysis and hydrometer testing.

Plasticity Properties (Soil Consistency)

Plasticity is the most important property for fine grained soils like silt and clay. In this scheme the soils are classified by delineating cohesive (clays) soils from non-cohesive (silts) soils.

It is important to determine plasticity properties of soils by simple laboratory or field procedures. These simple tests should be used by the Engineer to make decision on design or construction works.

SOIL DESCRIPTIONS

Soil descriptions and nomenclature are based on both size and plasticity or consistency properties. Descriptions are normally derived from two widely used systems as **Unified Soil Classification System** (USCS) and **American Association of State Highway and Transportation Officials** (AASHTO).

TABLE 2 - C1 DESCRIPTIONS USING PARTICLES SIZE

Major Division	Characteristics	Soil Type		Particle size range (mm)	
				AASHTO	**USCS**
Coarse Grained Soils	Larger particles and generally (= or > 50%) retained on sieve no. 200 i.e. > 0.074mm	Gravel			2.0 - 1.0
		Sands	Coarse sand	2.0 - 0.425	1.0 - 0.5
			Medium sand		0.5 - 0.25
			Fine sand	0.425 - 0.075	0.25 - 0.05
Fine Grained Soils	Fine particles generally passing through sieve no. 200 i.e. = or < 0.074	Silt		0.075 - 0.002	0.05 - 0.005
		Clay		0.002 - 0.001	< 0.005
		Colloids		< 0.001	
		Organic		N/A	N/A
		Peat		N/A	N/A

Description of Soil Samples or Deposits

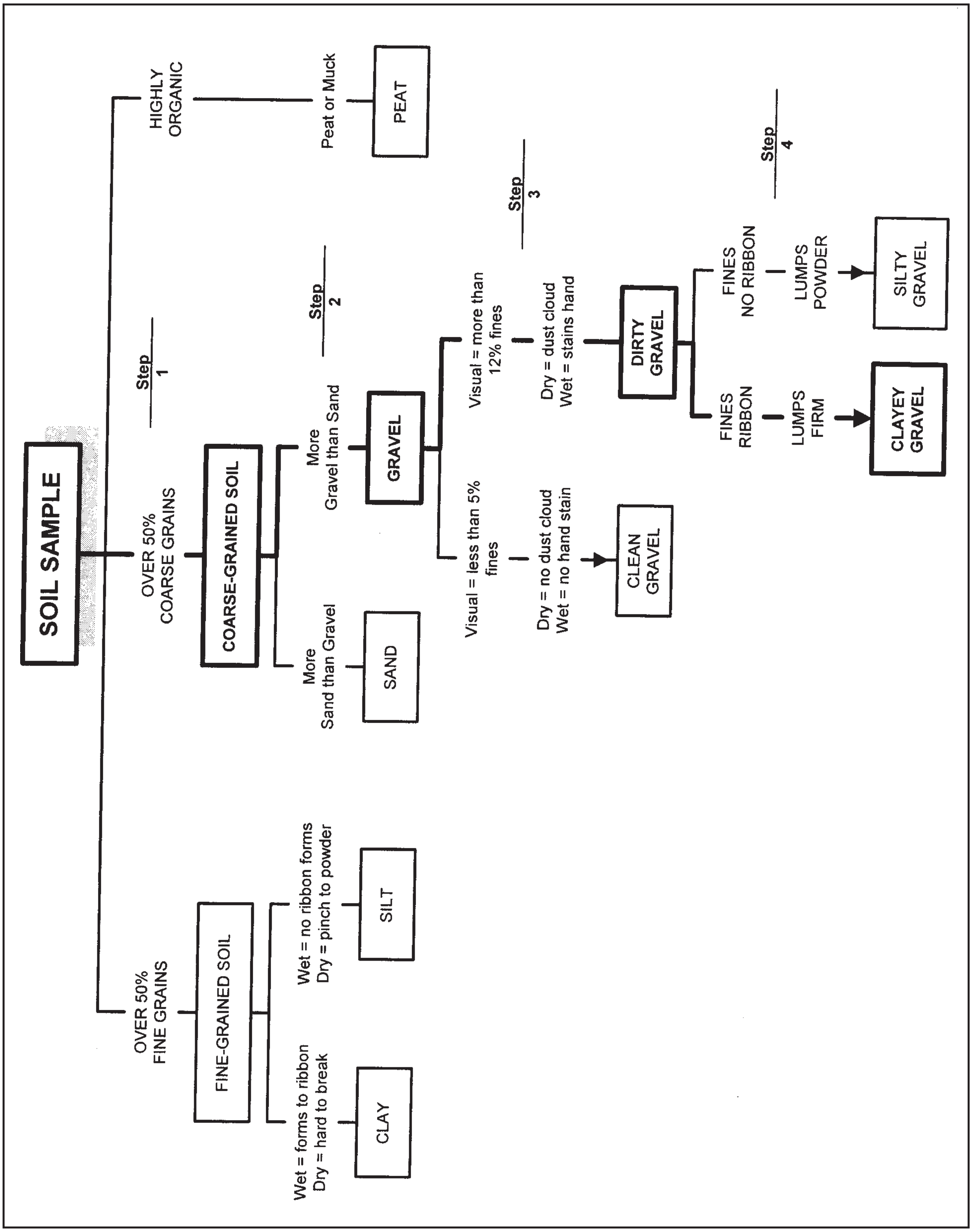
Soils in their deposits exist in combined form of various particle sizes distributed in different proportions. This makes the samples to show varying overlapping or combined characteristics comprising particle size distribution and plasticity properties.

Therefore in their deposits, soil samples can also be described as **well graded** or **poorly graded** depending on the particle distributions in the sample. Further in the case of fine grained soils deposits or samples can be described as of **high compressibility** or **low compressibility** soils.

SOIL IDENTIFICATION PROCEDURES

The identification procedure shown in **Figure 1-C1** is based on the Unified Soil Classification System (USCS). It uses the simple field tests to measure the suitability of various soils that you may come across. Detailed tests for gravel selection may be conducted in the laboratory. The user should make sure that he/she consults the criteria in this figure during any field examination of soil for selection.

FIGURE 1-C1: FIELD SOIL IDENTIFICATION PROCEDURE



SOIL STRENGTH AND SUITABILITY FOR ROAD WORKS

For gravel roads, the selection of a design subgrade or road surface gravel material is a significant step in the design and construction process. Design decisions must be done with limited descriptions of soil condition. If possible a test must be conducted to determine actual strength. However each component of road may also require different material characteristics. **Table 3-C1** provides a summary of soil strength characteristics and their suitability as road construction materials

TABLE 3 - C1 SUMMARY OF CHARACTERISTICS OF SOILS FOR ROAD WORKS

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	Very poor	Not suitable
Organic	-	Very high	Very poor	Very poor	Not suitable

EFFECT AND STABILITY OF SOILS IN CUTS

Cuts in soils or rocks stand at or near vertical. Usually the side slopes are made steeper than the original ground slopes and land slides may occur during construction or at later date.

The risk of sliding may be reduced by flattening the cut slopes, but this solution may not be practical in mountainous terrain. Another way to reduce the slide is to step the side slopes (benching). Even in such places where the slopes may be flattened, the most economical solution is to reduce the slopes only where the slides may occur.

Table 4 - C1 Recommended slopes for different soil types

Soil Type	Slope Inclination
Cohesion less sands	1 : 2
Silty sands - Silts	1 : 1
Alluvial soil (red friable clays)	1.5 : 1 to 3 : 1
Weathered rock	2 : 1 to 4 : 1
Sound rock	5 : 1 to 10 : 1

MATERIAL FOR EMBANKMENTS

Embankments are used in road construction when the vertical alignment of the road has to be raised above the existing ground level. Embankments in rural roads are only about 0.5 ~ 1.5 metres high.

In construction of embankments it is important to note that:

- High embankments impose a heavy load on the underlying foundation soils.
- The stability of the embankment slope depends on the fill material (soil) used.
- The speed of construction has a bearing on the stability of the embankment and its foundation.

Foundation conditions, settlements and Stability

If the foundation soil of the embankment is weak, a settlement may occur. If the soil is extremely weak a slip failure may occur. Settlements may be finished at the end of construction.

The foundation stability will depend on the dimensions of the base and thickness of foundation material. Expert advise is necessary when dealing with difficult situations. Any weak foundations soils must be removed and replaced with suitable material.

Slope stability

Embankments made from soils of low plasticity can be constructed with slopes as steep as 1.0 : 1.5 (vertical : horizontal) without causing slope stability problems. In other soil types, particularly in wet climates, the maximum slope may be 1 : 2. Where the embankment is subjected to flooding, the slope should not be steeper than 1 : 3.

MATERIAL FOR ROAD PAVEMENT OR SURFACE MATERIAL

This section is concerned with use of granular soil materials for road pavements constituting road surfacing. Typical requirements of soil materials for use as base and sub-base layers may be obtained by readers from other soil or highways publications.

Two important characteristics of granular materials are gradation of the gravel – sand particles and plasticity properties of the fines or silt – clay particles.

Gravel Wearing Course

The requirements and improvements for gravel wearing course are provided in **Table 5-C1**. The requirements and designs of the gravel materials provided in the table have been deduced from experience and take into account conditions of subgrade material, weather, and traffic load. The Engineer may provide different specifications after undertaking design based on these factors.

The quality and design requirements of materials specified in the Table should be verified by use of laboratory or simple field tests.

Good gravelling materials should contain between 35 ~ 65% stones, 20 ~ 40% sand and 10 ~ 25% clay. However, in wet weather a high proportion of clay in the mixture would make the layer too soft and slippery. The wetter the area the more important it is that the stone/sand proportion of the mixture is high and well graded. In a dry climate, a higher proportion of clay can be accepted.

Alternative Surface Materials

It should be noted that alternative surface materials may replace gravel in special cases. These are however treated in **Section F3** of this Manual.

IMPROVEMENT OF MATERIAL QUALITY

Natural soils consisting mainly of gravel or coarse sand, with finer particles to fill the voids and a small proportion of clay to function as a binder, may be improved and used to form strong running surfaces, bases or subbases. These soils may be as dug or mixtures from different sources to provide a stable material.

Two methods primarily used to improve the the quality of granular soil material used in low-volume road construction include mechanical stabilisation (compaction) and chemical stabilisation.

Compaction

This process involves packing soil particles close together thus increasing its density. Compaction of the soil materials has the following effect:

- Reducing the voids in the soil
- Increasing the bearing strength
- Improving the resistance to densification under loading traffic conditions
- Reduce the permeability
- And increasing shear strength

Compaction requirements

Compaction requirements are commonly specified by use of the end product specification. The required state of compaction is normally specified relative to laboratory tests. For instance compaction to 95% means that the dry density of the samples taken in the field should be 95% of the dry density obtained in specified laboratory compaction test.

Compaction tests on the soil sample must be done and the result used to define the required density. During construction the densities obtained in the field are determined and compared to the required density. The simplest method for the measuring field densities is the use of sand cone.

Optimum moisture content is necessary because it makes the compaction process easier (*i.e. by causing the soil to mould into formed lumps*) and facilitates the binding process to improve strength and stability. The optimum moisture content is different for each type or sample of soil and usually varies between 8% and 10%. The moisture content can be tested using simple field test (*i.e. hand test*) or laboratory test described later in this section.

It is recommended that the materials for embankment and the upper 50 cm of the subgrade in cuts is compacted to a minimum of 95% of the maximum dry density. For the lower layers of the embankment, the requirement is reduced to 90%.

For gravel surface material the minimum of 95% of the maximum dry density should be achieved. Minimum of 93% of the maximum dry density may be tolerated when using light equipment as in labour-based road construction.

Compaction Methods

There are basically four methods of compaction:

1. Manually or mechanically operated tampers or rammers
2. Deadweight rollers
3. Vibrating compaction
4. Natural consolidation/compaction

Chemical Stabilisers

The use of chemical additives can be a very efficient way to improve the properties of almost all road building materials. The stabilisers improve both the immediate and long term strength of the materials.

The use of stabilisers is however not very common in the construction of district or rural roads in Uganda because they are not economical. There use is therefore not widely treated in this manual.

TABLE 5-C1 REQUIREMENTS FOR GRAVEL WEARING COURSE

MATERIAL REQUIREMENTS FOR DISTRICT ROADS

GRADING REQUIREMENMT AFTERCOMPACTION		
SIEVE(mm)	% BY WEIGHT PASSING <150 VPD	% BY WEIGHT PASSING >150 VPD
40	100	100
28	95 ~ 100	100
20	85 ~ 100	95 ~ 100
14	65 ~ 100	80 ~ 100
10	55 ~ 100	65 ~ 100
5	35 ~ 92	45 ~ 85
2	23 ~ 77	30 ~ 68
1	18 ~ 62	25 ~ 56
0.425	14 ~ 50	18 ~ 44
0.075	10 ~ 40	12 ~ 32

TRAFFIC VOLUME (VPD)	<150	>150
CLIMATIC CATEGORY	WET	DRY
Liquid limit (%): L (greater-than or equal-to)	35	35
Plastic Index (%): PI	5 ~ 15*	10 ~ 30*
Plasticity modulus	200 ~ 1200	200 ~ 1200
4 day soaked CBR (%) (greater-than or equal-to)	25	25
DCP Equivalent (mm per blow) (less-than or equal-to)	9	9

* In dry areas, **PI** tends to higher values, however, in wet areas **PI** values are not allowed to exceed 15%.

MECHANICAL STABILISATION

If suitable natural gravel is not available, it may be possible to achieve the aboverequirements by mixing or mechanicalstabilisation of different materials.The requirements will apply to mixtures ofnatural gravel and sand or up to 30% of stone (crushed or not crushed).

NOTES

- California Bearing Ratio (CBR) at 95 % Maximum Dry Density (MDD), Modified AASHTO, and 4 days Soak.
- Dynamic Cone Penotrometer (DCP) using 600 cone.
- The lower quality material (CBR 15) may be accepted if no better material can be economically found.

CONSTRUCTION PROCEDURES

Minimum thickness of compacted layer :

District Class I Roads:	0.15m
District Class II Roads:	0.12m
District Class III Roads:	0.10m

PROCESSING: Use of sledgehammer may be necessary to break down coarse particles.

COMPACTION: Minimum dry density; normally 95% MDD (Modified AASHTO)

Higher relative compaction may be specified, to increase bearing strength, provided the module hardness is adequate.

Compaction and moisture content : between 80 and 105% OMC (modified AASHTO).

Maximum thickness compacted in one layer : 200mm (loose)

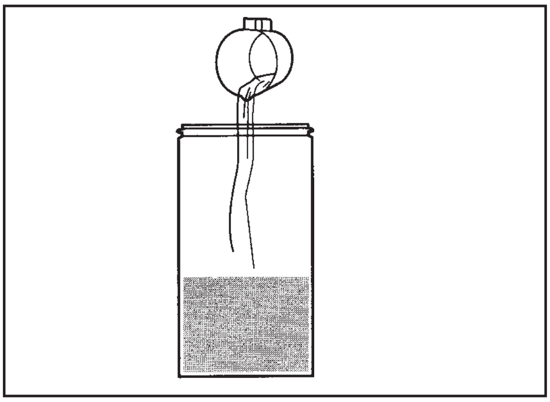
FIELD TESTS FOR IDENTIFYING SOILS

The soil tests discussed here provide good indications of the suitability of soils where laboratory facilities are not readily available. However, laboratory tests are always necessary when detailed soil classification is required.

Settlement test (for testing grading)

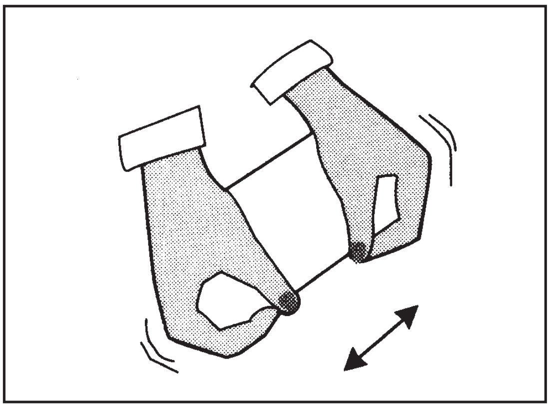
Step 1. Place the soil sample in a medicine bottle or a glass jar (*approximately 2 litres*) with straight sides such that the jar is half filled with soil. Add potable water until the jar is 75% full and add a spoon of salt to it. (*The salt will improve the settling process*).

FIGURE 2-C1



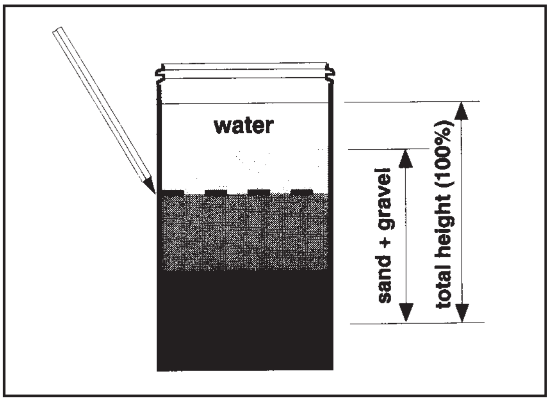
Step 2. Close the lid, shake vigorously and allow the soil to settle. Gravel and coarse sand will settle immediately, fine sand and coarse silt more slowly, taking about 30 seconds. Any clay or silt will take as much as 3 hours to settle. Organic material will tend to float on top of the water.

FIGURE 3-C1



Step 3. After the sample has settled for some hours, check the approximate quantities of each size that can be seen as layers. The content of any soil type present will be the height of that layer expressed as a percentage of the total height of the solid material that has settled, e.g. if the height of the gravel layer is **G** mm, the height of the sand layer is **S** mm and the total height of the solid material is **T**, then the percentages of gravel and sand, respectively, in that sample are:

FIGURE 4-C1



Gravel (%) = (G / T) x 100

Sand (%) = (S / T) x 100

Step 4. It is most convenient to collect a sample of the fines at the end of this test for the purposes of testing for the plasticity *(i.e. if the fines exist)*. The easiest way to collect this sample is to keep the sample jar in the sun until the water has almost evaporated. With a spoon, carefully remove the fines from the top without collecting coarse material. This becomes the sample for the moulding test and the drying test.

FIGURE 5-C1

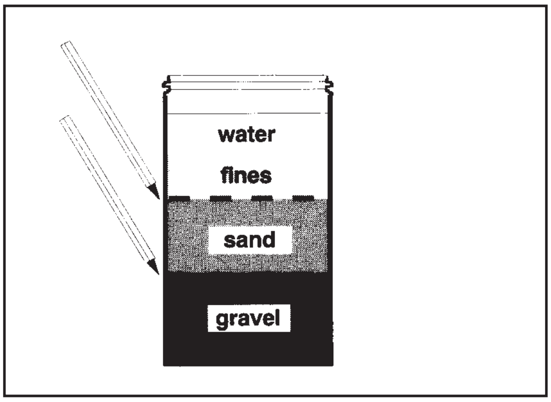
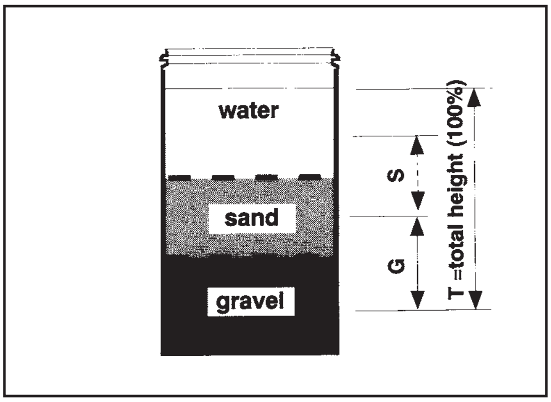


FIGURE 6-C1



Moulding test (for testing plasticity)

Step 1. Having collected a sample as described in Step 4 of the settlement test, try to form ribbons of thread with your hand on a smooth table or board. The material needs to be moist to do this.

FIGURE 7-C1

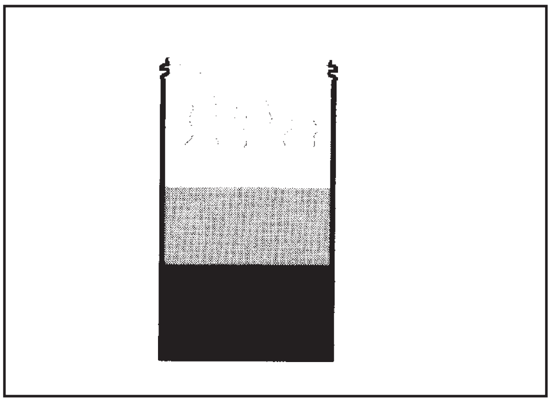
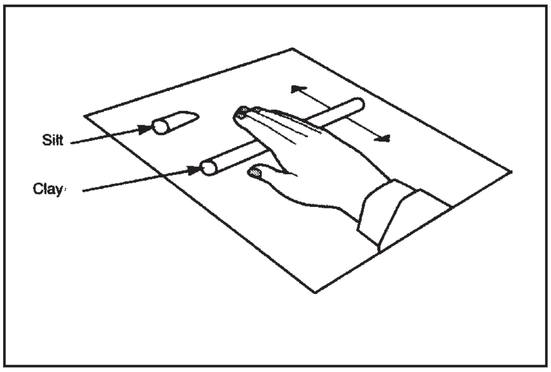


FIGURE 8-C1



If the fines are mainly clay, it will be possible to form the ribbons and the hands will be stained by the wet sample. This will indicate a high plasticity.

If the fines are mainly silt, the ribbon will crumble or be very short and the soil will not stain the hands. This will indicate a low plasticity.

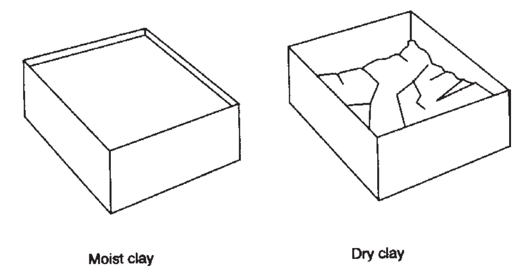
Drying test (for testing plasticity)

Step1. Having collected a sample as described in step 4 of the settlement test, fill the material evenly in to a matchbox and let it dry. Note that the material needs to be moist at the beginning of this stage.

If it is clay, it will crack and shrink.

If it is silt, it will not crack and shrink but will tend to crumble when touched.

FIGURE 9-C1



Hand moisture content test

On the construction site, the best way to check if the material is within the required moisture content range is by performing a simple test, which requires no testing equipment and provides quick results.

Squeeze a sample of soil in your fist.

If it feels moist or runs out between the fingers, the soil is too wet for compaction. The moisture content is well beyond 105%.

If, when the hand is opened again, the clay in the soil sticks in the fingers and the palm, the soil is once again too wet for compaction.

If after being formed into a ball, (*about 3cm diameter*), the sample breaks neatly into large pieces when being squeezed between the thumb and forefinger, it has approximately the correct moisture content for compaction.

If the material cannot be moulded into ball, the material contains too little moisture for compaction.

C2 CONCRETE

DEFINITION OF CONCRETE

Concrete is a mixture of cement, water, sand and stone. Other materials (admixtures) are sometimes used in addition to these to improve certain qualities of concrete.

Good concrete is one of the most useful construction materials because it can be formed to almost any shape while it is still fresh. When it sets and hardens it becomes strong and durable and requires very little maintenance.

PROPERTIES OF FRESH CONCRETE

The quality of fresh concrete is good if it is workable, cohesive and does not bleed too much while it is setting. It is also important to know that concrete can shrink and that heat is given off while concrete is setting and hardening.

Workability

Concrete is workable if it is easy to place and compact it with available equipment. The slump test is usually performed to measure the workability of concrete, but other tests exist for testing special types of concrete.

A low slump measurement means that the concrete is stiff and will have to be vibrated to compact it properly. If the concrete is sloppy, it will have a higher slump than a stiff mix and can be compacted by hand.

Concrete that will be vibrated should have a slump of about 35 to 75 mm. Concrete that will be hand compacted should have a slump of about 75 to 125 mm.

If the workability and slump of a mix is not right, it can usually be improved if the quantity of sand and stone in the mix is changed.

Under normal circumstances, water must not be added to concrete to make it more workable.

Cohesiveness

Concrete must be cohesive. This means that it must be sticky enough to prevent the stones from separating from the mortar when it is being transported, placed and compacted. Cohesiveness can be improved by the following means:

- Making the concrete stiffer
- Using smaller stones
- Using more of the very fine material in the mix such as dust from the sand or stone.

The cohesiveness of concrete can be judged by tapping the base plate of the slump apparatus after the slump has been measured. Cohesive concrete will settle without stones falling out of the lump.

Bleeding and settlement

When fresh concrete has been compacted, some water usually rises to the top surface after a while. This is called bleeding. It happens because the cement, sand and stone are always denser than water and settle slightly. Bleeding continues until the concrete sets. Too much bleeding can cause ugly patches on concrete surfaces and it may weaken the concrete and cause cracking. Bleeding can be reduced by:

- Making the concrete stiffer
- Using more of the very fine material in the mix such as dust from the stone or sand or extra cement.

Plastic shrinkage

If concrete loses some of its mixing water after it is compacted and before it sets, it shrinks slightly. This is called plastic shrinkage and it can cause severe cracking.

The loss of water is mostly due to the heat of the sun and hot dry winds blowing over the concrete. It can also be caused by the use of absorbent formwork or by casting concrete on dry ground. Ground on which concrete is to be cast should be prewetted and concrete should be protected from drying out. If cracks are noticed in time they can be closed up by re-compaction of the concrete.

Setting

When concrete is mixed, the water and cement react with each other. This reaction is very slow at first, but after an hour or two, the concrete starts to stiffen gradually. The stiffening continues until the concrete changes into an unworkable solid material. This stage is called setting. On average, concrete sets after 3 or 4 hours.

Heat of hydration

The heat that is given off as the water and cement in the concrete react is known as the heat of hydration. The temperature of the concrete normally continues to rise for many hours after mixing.

If concrete is cast in thin sections, such as drift slabs, the heat is lost so quickly that it may not be noticed. If the concrete is insulated or cast in thick sections, the heat cannot escape quickly and the concrete gets warmer. This rise in temperature can cause cracking of the concrete. It is advisable to take special precautions if concrete thickness exceeds 1.5 metres.

PROPERTIES OF HARDENED CONCRETE

Strength

After concrete has set, it develops strength. Strength development is fastest during the first day or two. It gradually slows down until after 28 days, when there is very little gain in strength each day. Concrete cannot gain strength if it dries out. For normal concrete, using ordinary Portland cement, the strength at 3 days will be about 50% of the 28-day strength. The strength at 7 days will be about 65% of the 28-day strength.

To make sure that concrete will continue to gain strength, it must be prevented from drying out too rapidly **and** it must be protected against very low temperatures. If this is done, then after 28 days the concrete will be very near its maximum strength.

The strength of concrete is measured by crushing concrete cubes which have been made and cured strictly according to a set of rules. The strength of concrete depends on:

- The age of the concrete

  Concrete gains strength with time, so it follows that the older the concrete the stronger it is.
- The ratio of water and cement in the mix

  Water **:** cement ratio = (mass of water in mix) **/** (mass of cement in mix)

  If the water **:** cement ratio is too high, the concrete will not reach the required strength.

  If the water **:** cement ratio is too low, the cement is being wasted.
- How well the concrete was compacted
- How well the concrete has been cured (curing is keeping the concrete moist after it has set)
- The temperature at which the concrete has hardened
- The type of cement used.

Strength is the most important property of hardened concrete.

Durability

Durability of concrete depends mainly on the water: cement ratio of the concrete and how well it is compacted and cured. High strength concrete is normally used in structures that have to be durable, e.g. bridges.

Permeability

Permeability describes the ability of the concrete to allow liquid to pass through it. High strength concrete is used where impermeable waterproof concrete is needed e.g. in water reservoirs.

Impermeable concrete can be made by:

- Using a low enough cement **:** water ratio for the mix
- Compacting properly and not allowing honeycombing in the concrete
- Curing thoroughly for a long time.

Drying shrinkage

When concrete is allowed to dry out, say after curing, it shrinks slightly. Although this shrinkage is small (about 0.3 mm per metre length) it can cause cracking in the concrete.

This problem can be overcome by adopting the following measures:

- Design the structure such that the concrete is free to move when it shrinks
- Divide the structure into fairly small pieces with joints in between.
- Put reinforcing steel into the concrete; the steel does not stop the shrinkage but causes many very small cracks instead of a few large ones

The amount of water that is used to make fresh concrete affects the amount of shrinkage that takes place when the concrete dries out. More water leads to more shrinkage.

Density

If ordinary sand and stone are used, the mass of a cubic metre of concrete is about 2400 kg.

MATERIALS FOR CONCRETE

Portland cement

The main materials used to produce Portland cements are finely ground 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.

There are many different types of Portland cement which can be used for different purposes. This manual shall only deal with **PC 15** which is the ordinary cement used in most construction sites.

Water

The water used in concrete reacts with the cement. It also wets the particles of cement , sand and stone to lubricate the mix so that the particles can slide and roll over one another when the concrete is worked.

Water is the cheapest material in concrete, but the quantity of water used can make a big difference to the quality of the concrete.

Potable water should normally be good enough for making concrete. Impurities in the mixing water can affect the time concrete takes to set, the strength of the concrete and the colour of the concrete. The impurities can also cause corrosion (rusting) of the reinforcement steel.

Acceptable water for use in concrete shall be:

- Clean and free from oil
- Free from impurities that may affect the durability of the concrete.

The water : cement ratio should not be more than 0.5 (Normally ranges between 0.4 and 0.5)

Sand

Sand is the **fine aggregate** used in concrete.

Sand, together with water and cement, forms **mortar**, this fills the spaces between the stones and coats them thickly enough to keep them apart. Sand also provides bulk to the concrete to make the concrete cheaper and more stable (less shrinkage).

The workability, cohesiveness and bleeding of concrete all depend heavily on the quality of sand.

Acceptable sand for use in concrete shall be:

- Clean river sand, free from dust, lumps, soft or flaky particles and organic matter.

Stone

Stone is the **coarse aggregate** used in concrete.

Stone is used to provide bulk in concrete and to make the concrete more stable (i.e. less shrinkage).

Acceptable stone for use in concrete shall be:

- Well graded and free from organic material.

STORING MATERIALS FOR CONCRETE

Storing aggregates (both stone and sand)

During transportation, storage and handling, aggregates must not be contaminated by impurities such as soil, clay, roots, leaves, fertilizer, sugar, salt, coal, etc. All of these can affect the quality of concrete.

The rules for good storage are:

- Do not place stockpiles under trees as leaves and seeds will contaminate the aggregates.
- Rain water should drain away from stockpiles.
- Aggregates should preferably be stockpiled on a concrete floor to prevent mixing with soil.
- If a concrete floor is not used for the stockpile area, then the ground on which the aggregates are stored must be cleared of grass and roots.
- Retaining walls and partitions separating different materials must be high enough and strong enough to withstand the pressure of the aggregates.
- Stockpiles should be at least big enough to contain all the material required for a day's concreting.

Storing cement

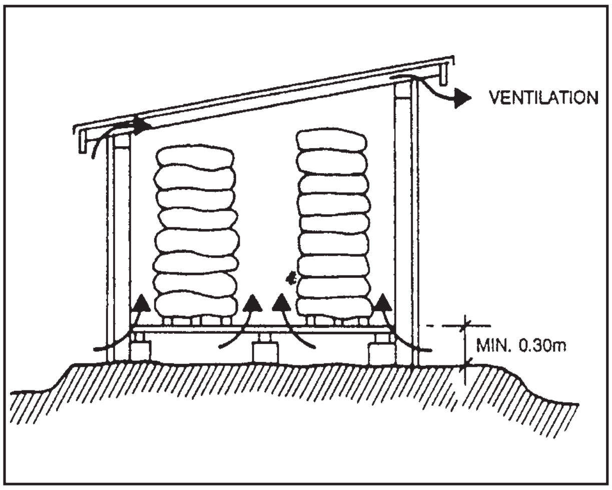
Good, dry storage of cement is very important. Concrete made with cement that has been exposed to moisture in the air or on the ground will be weaker than concrete made with fresh cement.

Lumps in cement are a sign that cement has been exposed to moisture. If this happens:

- As a rough guide on site, if the lumps cannot easily be broken between the fingers, do not use the cement for any mix apart from concrete class lean for blinding.
- For the class lean concrete, you can either sieve out the lumps or increase the amount of cement in the mix by adding an amount equal to the lumps in the cement bag.

The rules for storing cement are listed below:

FIGURE 1 - C2 STORAGE OF CEMENT



- The cement must be stored in a weather proof store which must have either a damp proof floor or a second floor of timber so that the cement bags will be clear of the ground.
- Torn cement bags or bags showing signs of dampness should not be accepted from the supplier.
- Stack bags close together, but keep a clear space between the sacks and the walls.
- Bags must be stacked not more than 12 bags high to avoid compaction of lower bags.
- Stack the bags so that the first batch in can be the first out.
- The cement store must have a well ventilated but dry atmosphere.

Storing bagged cement in the open

If it becomes necessary to store sacks of cement in the open, you should;

- Make a wooden platform about 300 mm off the ground supported on bricks or timber.
- Cover bags with a tarpaulin or plastic sheeting. If more than on sheet is used, overlap them so that water runs off without wetting the bags.
- Weigh down the sheeting at the bottom and on top with reasonable weights that will not allow the wind to blow the sheeting away.

TYPES OF CONCRETE

There are three principal types of concrete required for use in district road works. These are determined by their mix proportions as described below.

Class Lean (1:4:8)

This is a meagre mix with low cement content. It is used for blinding the foundation excavations, for structures, where it acts as a clean working surface prior to placing mass or structural concrete. The mix proportions (cement **:** sand **:** stone) are 1 **:** 4 **:** 8.

Class 15 (1:3:6)

This is appropriate for gravity 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 mix proportion is 1 **:** 3 **:** 6.

Class 20 (1:2:4)

This is concrete intended for use in reinforced structures and load bearing applications such as culvert rings. It is a higher strength of concrete and the maximum aggregate size is normally 20 mm to allow the concrete to easily pass around steel reinforcement.

Note that there are higher classes of concrete (**25**, **30** and **40**) that are used in special cases. These are not normally required for feeder road site works.

ESTIMATING QUANTITIES OF MATERIALS FOR CONCRETE WORK

The method used to estimate the quantity of each material depends on whether the concrete is being batched by volume or by mass. Batching is the measuring out of the quantities of materials to be used in the concrete mix. It is important to batch the materials correctly, because the amounts mixed can affect the workability, strength and cost of concrete used.

Batching by mass is usually more accurate than batching by volume. Batching by mass is usually recommended for higher strength concrete (class 25 and above). Volume batching is adequate for most district road concrete work.

Batching by volume

Cement

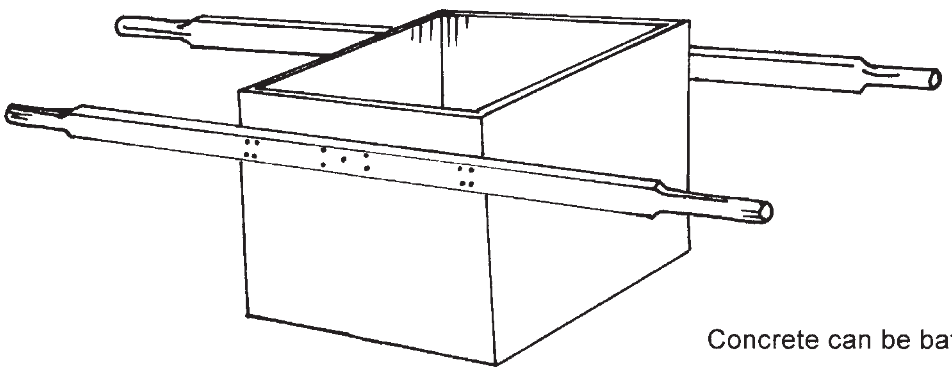
Because cement fluffs out and increases in volume when poured out of the cement bag, it is not advisable to batch cement by loose volume. Whole bags of cement should be used.

Sand and stone

The following points should be noted when batching sand and stone by volume:

- There should be enough gauge boxes to measure all the materials for each batch of concrete without using any container more than once.
- Material in gauge boxes must not be compacted when filling up.
- The gauge box must be filled level with the top in order that the volume of material measured out is equal to the volume of a bag of cement.
- Never use a shovel as measure for volume batching.

FIGURE 2 - C2: GAUGE BOX



Concrete can be batched by volume.

Gauge Boxes made from steel, wood or plywood are used for this

Volume

0.036m³ or 36 litres.

36 litres are equal to 1 (50 kg) bag of cement

Box dimensions

Inside measurements

Length	Width	Height
400mm	300mm	300mm

TABLE 1 - C2 ESTIMATING QUANTITIES FOR VOLUME BATCHING - CONCRETE MIX PROPERTIES

CONCRETE CLASS	NOMINAL MIX BY VOLUME (maximum aggregate size)	BATCH WITH ONE BAG OF CEMENT			MATERIAL REQUIRED FOR ONE CUBIC METRE FINISHED CONCRETE (APPROXIMATE)		
		NUMBER OF GUAGE BOXES OF AGGREGATE		APPROX. YIELD PER BATCH (M^3)	CEMENT IN BAGS (kg)	SAND (M^3)	STONE (M^3)
		SAND	STONE				
LEAN	1 : 4 : 8 (40)	4	8	0.30	3.3 (166 kg)	0.47	0.94
15	1 : 3 : 6 (50)	3	6	0.24	4.3 (215 kg)	0.46	0.92
20	1 : 2 : 4 (20)	2	4	0.16	6.0 (300 kg)	0.42	0.84

MIXING CONCRETE

Concrete can be mixed either by hand or by mechanical means. Both methods are discussed below.

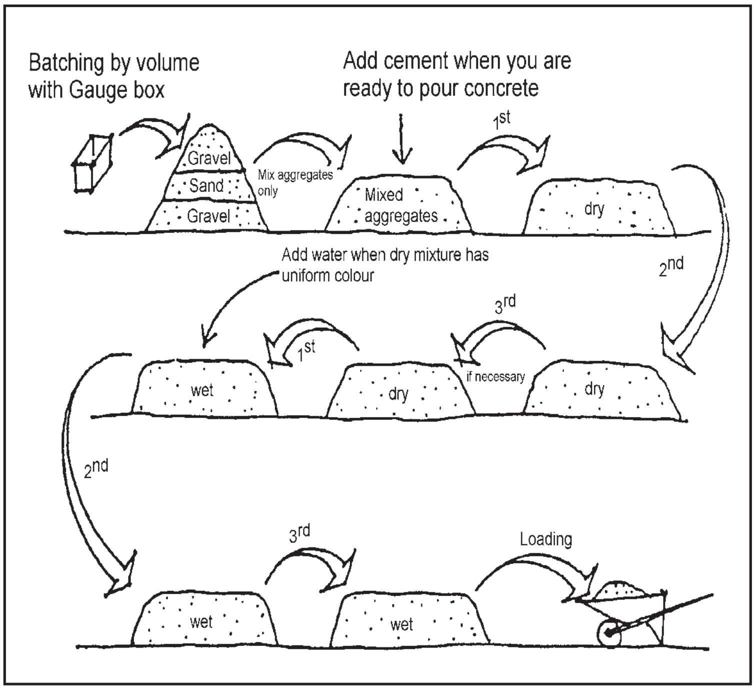
Hand mixing

The aggregates and cement are thoroughly mixed to uniformly blend with the cement before water is added. A further thorough mixing operation is required to evenly disperse the water and make the concrete workable for use.

Concrete should never be mixed on soil. A platform must be built with boards, with metal sheets or lean concrete. The size of the platform will be such that a continuous mixing process is possible (e.g. 4m x 6m).The platform should be thoroughly cleaned after use each day.

Prolonged skin contact with cement or concrete should be prevented by protective clothing such as gloves, overalls and boots.

FIGURE 3 - C2 ILLUSTRATION OF HAND MIXING CONCRETE



The recommended procedure for mixing concrete by hand is outlined below:

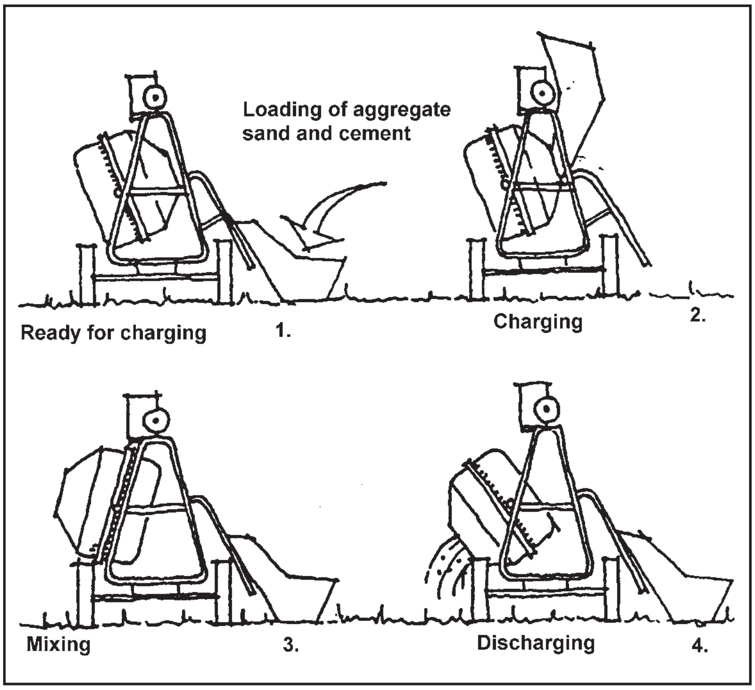
1. Batch coarse and fine aggregate (i.e. stone and sand) by volume such that the total volume of the batch is not greater than 0.5 m^3.
2. Place the stone and sand on the platform in alternate layers and mix thoroughly by turning the heap over several times.
3. The most efficient method of mixing the materials is by two workers facing each other and working from opposite sides of the heap. Working from the outside to the centre, they turn the material from the heap onto a new wide, flat heap (conical heaps encourage segregation). This is repeated at least twice.
4. Add cement on top of the heap of sand and stone when concrete is about to be poured. Note that no water is introduced at this stage. Once again, the heap is thoroughly mixed in the same way as described in paragraph 3 above, until the batch is a **uniform colour**.
5. Add water by sprinkling the pre-determined quantity gradually on the heap while it is turned over another three times. As the water : cement ratio exceeds 0.3, water should be added more carefully in order to get the best workability without exceeding the water :cement ratio of 0.5. Mixing should be done until the mixture is a uniform consistency and sufficient workability has been reached.

It must be borne in mind that sand and stone normally have some residual moisture content at the time of batching. The maximum residual moisture contents shall be 1% for stone and 5% for sand.

Mechanical mixing

Mechanical mixing produces a more homogeneous and better mix. A large number of different types of concrete mixers exist. The most common type is the tilting drum mixer. In this type of mixer, a drum rotates on an inclined axis when mixing and on a tilted axis for discharging. Three positions are used:

FIGURE 4 - C2 ILLUSTRATION OF CONCRETE MIXER POSITIONS



- Charging position (i.e. loading cement, sand gravel)
- Mixing position
- Discharging position

The capacity of a concrete mixer is usually described by 2 quantities.

The first quantity is the **CHARGE**. This is the total loose volume of sand, stone and cement that can be loaded into the mixer.

The second quantity is the **YIELD**. This is the maximum volume of wet concrete that can be produced , or discharged by the mixer.

The charge and yield of the concrete mixer are usually measured in litres. The description of the concrete mixer is normally written as, say 750/500, which means that the maximum charge is 750 litres and the maximum yield is 500 litres. Typical concrete mixer sizes range from 50/35 to 1500/1000

Efficient mixing can be achieved by following the guidelines below:

1. 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 (i.e. loading) the mixer with a small quantity of stone and water, mixing for a while and then discharging the cleaning material.
2. The mixer should be loaded or charged in the following order:
   a. Stone and most of the water
   b. Cement
   c. Sand
   d. The rest of the water
3. Do not overload the mixer. Overloading leads to poor mixing, spillages and waste of materials.
4. Mixing time should be long enough to produce a mix of uniform texture and colour. Mixture manufacturers provide information on mixing times. A small amount of over mixing is not serious, but under mixing could be disastrous.

TRANSPORTING CONCRETE

Concrete must be transported from the place of mixing to the placing position as quickly as possible (i.e. within 30 minutes) and in such a way that the quality of the concrete is not affected.

Methods of transporting concrete

There are many ways of transporting fresh concrete to the point of placing. The choice depends, among others, on:

- the type of job
- the size and lay out of the construction site
- the rate of production of fresh concrete

Concrete can be transported by using any of the following means:

- Ready-mixed concrete trucks
- Skips (with hoists or cranes)
- Pumps
- Dumpers
- Wheelbarrows
- Headpans

The most common methods of transporting concrete in district roadworks activities are wheelbarrow and headpans.

Maintaining the quality of concrete during transportation

The following points require attention and supervision when concrete is transported:

- The concrete should not dry out and loose workability due to exposure to dry wind, hot weather, etc. Concrete should be placed as soon as possible after mixing. If delays in placing concrete do occur, then concrete that is transported in open headpans or wheelbarrows should be covered with plastic sheets or tarpaulins to reduce drying out.
- Leaking wheelbarrows or headpans should **not** be used for transporting concrete as loss of concrete fines may occur.
- The wheelbarrows or headpans must be thoroughly cleaned before being used to transport fresh concrete to avoid contaminating it with other materials such as soil, old concrete, etc.
- Concrete should not become diluted with water. Rain water in wheelbarrows or headpans 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.
- If concrete is transported in wheelbarrows, the haul routes should be kept smooth to prevent segregation during transportation. If it is not possible to prevent segregation during transportation, the concrete must be remixed before it is placed. This problem is usually minimal with headpans as the person carrying the pan acts as an efficient shock absorber.
- The concrete should not be allowed to stiffen or set during transportation. Higher concrete classes are more susceptible to stiffening than the lower grades, particularly in hot weather if the transportation time is too long.

PLACING CONCRETE

The most common problems that occur when concrete is placed in position are listed below:

1. Rubbish such as saw dust, wood shavings, wire, etc. is left in the formwork and contaminates the concrete.

   The problem can be eliminated by inspecting and cleaning the formwork just before the concrete is placed.

2. Cold joints can occur between layers of concrete if there is too long a delay in placing successive layers.

3. Segregation takes place and causes honeycombing in the concrete.

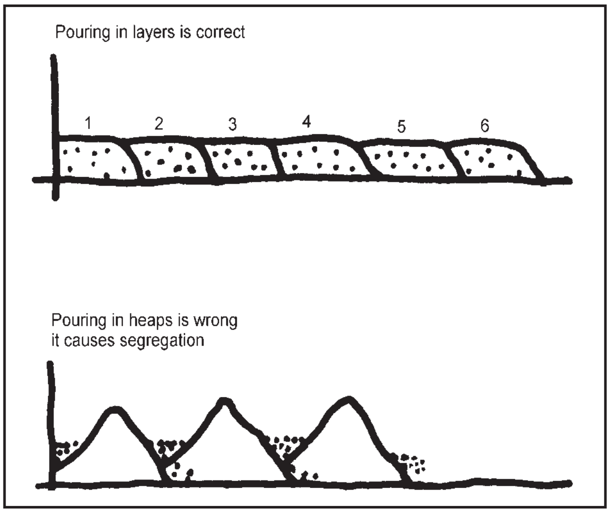
   Segregation that is caused when concrete is placed can be prevented by applying the following rules:

   - The concrete should always be placed as closely as possible to its final position. It should be placed into corners and into working faces and not away from them.
   - Do not move concrete sideways after placing, especially with a poker vibrator.
   - In deep pours, such as abutments and piers, do not allow the concrete to fall onto the reinforcement because some of the mortar will remain on the bars while the stone falls to the bottom.

     The best way of preventing segregation in deep pours is to increase the amount of mortar in the first batch of concrete that is poured. The easiest way to do this is to leave out half of the stone and adjust the water : cement ratio accordingly to give the right slump.

     Another way is to use a wooden or steel funnel to pour the concrete. This will not only prevent segregation but may also prevent pouring of concrete outside the formwork. The mouth of the funnel should be approximately 50 cm above the bottom of the form to start with and must be lifted at the same rate as the rising concrete.

     FIGURE 5 - C2 ILLUSTRATION OF PLACING CONCRETE

   - When concrete is being placed in sloping lifts, such as drift and/or causeway approach slabs, placing should start at the bottom and work upwards in horizontal layers.
   - When concrete is placed around horizontal void formers, it should be placed from one side until it can be seen from the other side to have filled the space under the void former.

Concrete must be placed in layers of maximum depth of 300 mm for hand compaction and 600 mm for mechanical compaction.

COMPACTING CONCRETE

Concrete must be properly compacted to remove all the air voids trapped in it.

There are several methods of compacting concrete but the most common in roadworks are:

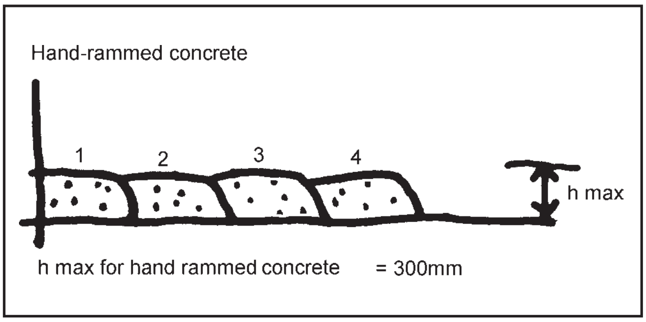
- Hand compaction (hand ramming) and
- Mechanical vibration (internal vibration using a poker vibrator)

Hand compaction

Hand compaction is normally used for concrete in wall foundations, unreinforced slabs and blinding layers. Concrete that will be hand compacted should have a slump of about 75 mm to 125 mm.

Spades and suitable pieces of timber are normally used to rod and compact the concrete. Gumbooted feet work very well for compacting concrete in footings.

FIGURE 6 - C2 PLACING OF CONCRETE AND COMPACTING BY HAND



For ground slabs, e.g. aprons, a heavy screed board is also used to compact the concrete. The board is used first in a chopping motion and, when mortar forms on the surface of the concrete, it is used in a sawing motion to screed the concrete to the correct level.

Small pre-cast items such as paving slabs can be compacted by jolting the mould on a concrete floor.

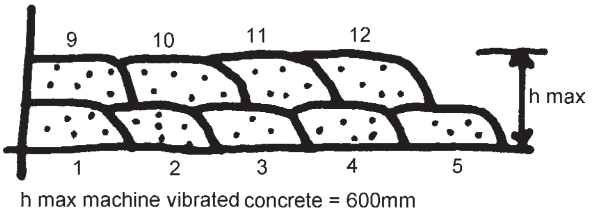
Mechanical vibration

Concrete that will be vibrated should have a slump of about 35 mm to 75 mm.

Internal vibration using a poker vibrator is the most common method of compacting concrete. To ensure good compaction, the following points are important:

- Concrete should be placed in layers not deeper than 300 mm and each layer should be vibrated before the next layer is placed. The poker should penetrate the layer below the one being compacted.
- The poker should be pushed vertically into the concrete as quickly as possible.

FIGURE 7 - C2 PLACING OF CONCRETE AND COMPACTING MECHANICALLY



- The poker should be withdrawn slowly from the concrete to avoid leaving behind a void.
- Compaction of the concrete is complete when air bubbles stop breaking through the surface of the concrete **and** the surface takes on a uniform sheen. Another sign that compaction is complete is that the sound of the vibrator changes, but it is not always easy to hear this. It takes approximately 15 seconds for full compaction at a particular point.
- The poker should be inserted at points about 300 mm apart, but this distance will depend on the concrete mix and the size of the poker vibrator.
- The diameter of the poker should be at least the size of the stone but it should be able to pass between horizontal reinforcing bars.
- Do not allow the poker to touch the formwork because the release agent may be removed or the formwork may be damaged.

PROTECTING CONCRETE

After concrete has been placed and compacted, it should be protected from damage for a few days. This is necessary because new concrete does not have enough strength to resist damage that can so easily occur on a construction site.

New concrete can be protected by:

- Erecting barriers to prevent people, animals, equipment and traffic from moving on the concrete.
- Protecting concrete slabs and floors from rain until they are at least 24 hours old.
- Diverting storm water around newly cast slabs, channels, etc.

CURING CONCRETE

Concrete must be cured, i.e. kept moist, for a number of days (at least 4 days but ideally 7 days) to prevent the concrete drying out prematurely before gaining sufficient strength. The concrete derives its strength from the prolonged reaction between cement and water.

If concrete is allowed to dry out too soon, the results could include cracking, unsatisfactory strength and poor durability.

The principal methods for curing concrete are self-curing and water-curing.

Self-curing

With this method of curing, the water used to mix the concrete is prevented from escaping from the concrete. This can be achieved in the following ways:

- Cover the concrete as soon as possible with plastic sheeting. The sheeting must be weighed down or tied down and must have wide overlaps. The edges of slabs must be well-covered.
- Leave the forms in place for as long as possible.

  This method can be used for sides of columns, beams and walls with the exposed top surfaces covered with plastic sheeting. If the forms are made of timber, they should be sprayed with water on the outside faces.

  If the forms are stripped before the curing period is complete, another method of curing should be started as possible.

Water-curing

With this method of curing, the concrete is prevented from drying out by keeping it wet with additional water. This can be done in the following different ways:

- Make a pond of water on the concrete.

  This can be used on large, flat surfaces such as slabs. The sides of the concrete must be cured in another way, e.g. by leaving the forms in place or covering the sides with plastic sheeting.
  Ponding should not be used for concrete cast on the ground as it may cause softening of the ground under the joints. Pre-cast concrete products such as pipes are often completely immersed in large ponds of water.
- Sprinkle water onto the concrete.
  This is a very effective method of curing concrete but the concrete should be kept continuously wet. The only safe way to ensure this is to sprinkle continuously.
  If sprinkling is interrupted, the concrete may dry out between wettings. This can cause fine cracks to develop on the surface of the concrete.
- Cover the concrete with a material like wet jute, sand, saw dust or banana leaves and keep it wet.
  The entire surface of the concrete must be covered, including the edges of slabs if the side forms are removed.
  The coverings must be kept continuously wet during the entire curing period. Some materials may discolour the concrete.

C3 FORMWORK

DEFINITIONS AND REQUIREMENTS

Formwork retains concrete until it has set and produces the desired shapes and sometimes, desired surface finishes.

Soffit formwork is used to support suspended reinforced concrete slabs and beams during pours and is mainly used for insitu bridge decks and box culverts.

Formwork must be supported on falsework of adequate strength and sufficient rigidity to keep deflections within acceptable limits.

The forms too must be strong and rigid to meet dimensional tolerances. But they also must be tight, or motar will leak out during vibration and cause unsightly sand streaks and rock pockets. Yet they must be low cost and often easily demountable to permit reuse. All these requirements are met by steel, reinforced plastic, and plain or coated timber and plywood.

MATERIALS FOR FORMWORK

Timber

Timber and plywood are commonly used materials for formwork because they can easily be cut and assembled on site. Another advantage of timber formwork is that it is relatively cheap compared to steel formwork.

Normally timber formworks are re-used for about three times.

Steel

Steel is mainly used for formwork systems that can be bought or hired '**off-the-shelf**'. These systems provide a simple way of dealing with repetitive work and can be re-used easily and quickly.

Steel forms are also sometimes specially designed and made for '**on-off**' jobs or sections of work. More than a hundred re-uses can be obtained with steel forms provided they are looked after properly.

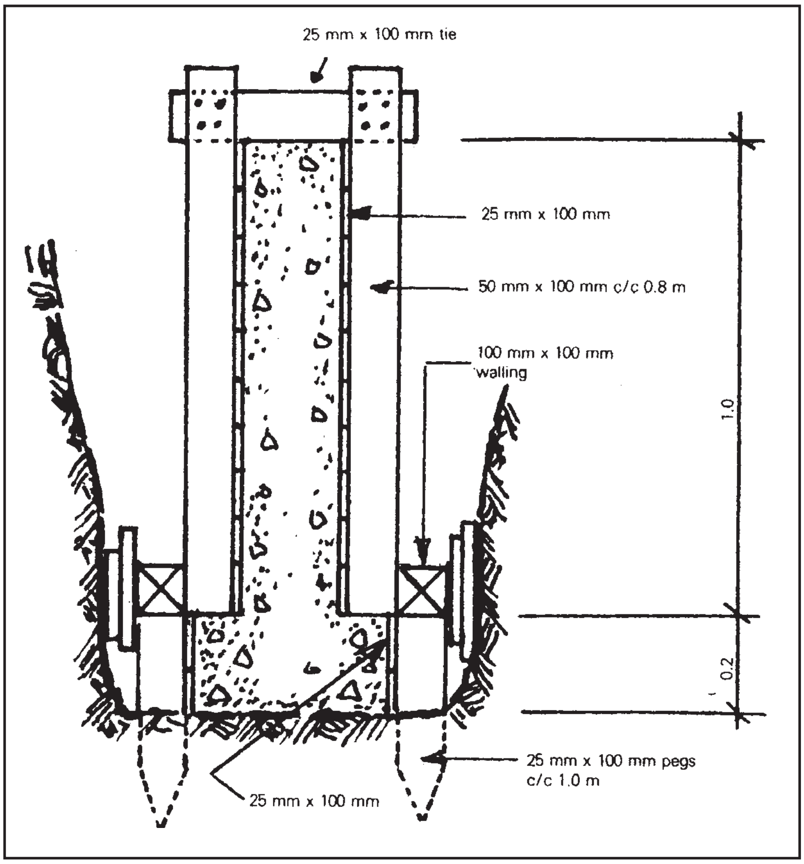
FORMWORK AS DEFINED BY POSITION OF USE

Simple Foundation Formwork

For foundation formworks, the finish is not critical and old shutter panels can be used. Alignment and deflection is not usually critical provided the shutters can cope with the concrete pour and vibrator loading. Ensure that shutters do not move after vibration as this will affect the quality of concrete.

If the ground is suitable and it is possible to dig vertically sided trenches, it is usually cheaper to slightly over dig the width of the trenches and eliminate formwork altogether by pouring concrete directly against the earth face.

FIGURE 1 - C3: SIMPLE FOUNDATION SHUTTERING



Ground slabs

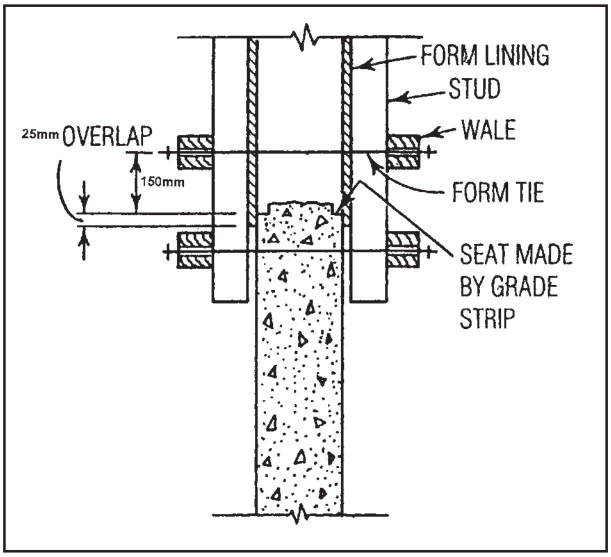
Ground slab forms may be used for constructions like that of drift slabs.There are various ways of making side forms for ground slabs. For all methods, the top of the side form will be at the finished slab level. Concrete is poured and spread and then vibrated using timber running on top of the side forms. The side forms must be totally rigid and the vibration timber beams will span across the two side forms.

Walls (retaining walls, piers, abutments, etc.)

When constructing formwork for walls note that:

- The shutters or studs normally consist of 18 mm exterior grade plywood supported by backing timbers of say 100 mm x 50 mm or 150 mm x 50 mm or similar size at 400 mm spacing. Backing support is provided by additional vertical members called soldiers (usually metal) and horizontal members called wales as required. The shutters inside face must be lined using plastic coating, proper oiling or effective wetting.

FIGURE 2 - C3: TYPICAL WALL CONCRETE FORMS OR SHUTTERING



- Small wall shutters (up to 2 metres high) can be built from experience but larger panels will require proper calculations for loading and deflection checks. These larger panels are normally prefabricated elsewhere and brought out to each site for use.
- For free-standing walls, shutter panels are used in pairs and to resist bursting forces, they are bolted together at a designed spacing by using "**tie bars**". Regardless of which type of tie bar is used, they will leave their mark in the finished concrete.
- The shutters are bolted up tight to grip or bite onto the previously formed kicker. (A **kicker** is a 75 mm protruding bit of concrete from the foundation which is poured to the cross sectional dimensions of the wall to be poured. It guides the erection of the formwork for the wall). If the kicker is correctly positioned, then the only problem in the erection of the formwork will be to plumb the shutters to obtain a good wall. Verticality is checked by use of a plumb bob, a builder's spirit level or a theodolite (where high accuracy is required).
- It is generally better to pour walls to full height in one pour as vertical joints are generally more successful than horizontal joints.

Columns (and similar structures)

- The formwork is very similar to that of walls. The cost of column shuttering generally increases with the complexity of the cross section. Rectangular columns are easier to adopt.
- Although columns are very narrow walls, an essential and very important difference is that columns require only small quantities of concrete (often just 1 ~ 2 m^3). This small quantity can be poured very quickly leading to high rates of pour and thus high pressure loading on the shutters.
- Due to the small cross section, column shutters tend to be less stable and have to be plumbed in two directions at right angles.
- Columns should always be poured to full height (unless agreement from the Engineer is obtained to pour less than full height). It follows that the formwork shall also be placed to full height of column.

Slabs (soffit formwork)

- Soffit formwork is used to support suspended reinforced concrete slabs during pours and is used for in-situ bridge decks, box culverts, etc.
- The deck normally consists of 25 mm exterior grade timber ply. This ply is supported on a system of timber joists:

  a. timber (100 mm x 50 mm or 150 mm x 50 mm or similar) directly in contact with ply

  b. cross beams (230 mm x 75 mm) supporting timber in (a) above
- The joists are supported by fork heads of a conventional scaffold or false work system. For twisting and stability reasons, do not use joists with height/width ratio greater than 3 : 1.
- The position of construction joints should be obtained from the drawings or from the Engineer, as their positions can be quite critical to the design of the soffit formwork.

RELEASE AGENTS

A thin coat of release agent must be applied to the surface of the formwork, before it is used, to make it easier to strike the form from the concrete face.

Different types of release agents are available. It is important to use the correct release agent or the type of formwork material that is being used. Expert advice should be obtained if there is doubt about which type of release agent to use. For minor works such as culverts, burnt oils can be used as a substitute.

CHECKS BEFORE CONCRETING

Formwork should be carefully checked and inspected after it has been erected and before concreting starts. The important points are:

- The formwork must be correctly aligned and levelled.
- Bolts must be tight and bolts must be driven home securely to prevent loosening due to vibration.
- Stop ends must be properly secured.
- Joints must be properly sealed to prevent leakage of cement paste or mortar.
- The props must be at the right spacing, plumb, properly tightened and locked. Sufficient diagonal bracing must be used.
- The reinforcement (if any) must be checked and sufficient spacers must be in position to provide the correct concrete cover.
- The forms must be clean and all rubbish, scraps of timber or steel must be removed.
- Ensure that the correct type of release agent has been applied.
- All the tools and equipment required during concreting and the material required for curing must be available.

REMOVING (STRIKING) FORMWORK

Table 1- C3 below gives guidance on the minimum age of concrete before striking should start.

- When the formwork is struck, ties and clamps should be loosened gradually to prevent the last tie from binding.
- If the forms do not immediately come away from the concrete, they should be carefully pried loose, using hardwood wedges.
- When soffit formwork is struck, the props should be removed evenly in stages starting from the middle of the span and working out towards the supports.
- '**Crash striking**', where large areas of formwork are dropped simultaneously should never be allowed. It is dangerous to workmen and it may damage the formwork and the structure.

TABLE 1 - C3: REMOVAL OF FORMWORK, MINIMUM AGE OF CONCRETE IN DAYS

Types of structural member or formwork	Portland Cement 15		Remarks
	Normal Weather	Cold Weather	
Beam sides, walls and unloaded columns	0.75	1.5	Normal temperature are between 15^0C to 32^0C Cold temperature are below 15^0C Shorter periods may be used for sections 300 mm or more thick
Slabs with props left under	4	7	
Beam soffits with props left under	7	12	
Slab props	10	17	
Beam props	14	21	

Constructn.Materials C
Formwork 3

CLEANING AND STORING FORMWORK

Formwork should be cleaned immediately after use and then stored until needed again.

Clean timber forms with a stiff brush to remove dust and grout. Use a timber scraper if necessary. Do not use steel scrapers on timber or plywood forms.

Steel forms should be lightly oiled to prevent rusting if they are not to be used for some time.

The main rule about storage is to avoid doing any damage. Usually, more damage happens to formwork when it is not in use than when it is being erected or struck.

C4 REINFORCEMENT

On site, reinforcement for concrete work must be properly stored and handled and it must be fixed and kept in the correct position during construction.

STORAGE OF REINFORCEMENT

The main rules for good storage of reinforcement are:

- Steel should be stored off the ground, especially on muddy sites.
  If the steel does become dirtied with mud or clay, hose it down and use scrubbing brushes to clean it.
- Steel should be stored away from workshops where oil and greases are used.
  Any oil or grease on the steel should be scraped or rubbed off and the steel should then be washed down with a strong detergent.
- Loose rust and mill scale must be removed from the steel, using scrapers or wire brushes, before the steel is fixed in position.
  Rust or scale that sticks firmly onto the steel does not have to be removed.

FIXING REINFORCEMENT IN PLACE

Reinforcement must be fixed in the correct position and care must be taken to keep it in the correct position while concrete is being placed and compacted.

The important points that require checking and supervision are:

- All reinforcing bars and mesh must be fixed in the positions shown on the engineer's drawings.
- The bars must be properly tied together with soft wire and the long ends of the wires must be clipped off.
- Sufficient spacers must be used to make sure that the correct concrete cover to the reinforcement is obtained in the whole structure.
- Spacers shall be made of well cured mortar. Wooden blocks, pieces of stone or brick must not be used for spacers.
- Spacers must be securely fixed to the reinforcement. They must not be able to rotate or move out of position when the concrete is being placed and compacted.
- Steel must not be trampled or pushed out of position by the concreting gang or the placing equipment.

Section D

Work Planning

Section D
Work Planning

WORK PLANNING

There are various levels of planning associated with roadworks. In the context of Uganda, we can place the planning of roads into three broad levels of planning as described below:

1. The first level of planning involves overall Ministry of Works, Housing and Communications policy which sets out the basis of all road development programmes within the country. The planning at this level involves, among others, setting the standards, preparation of long-term programmes and coordination of all roadworks within the country. Some of the planning involved at this level is discussed in **Volume 1 Manual A** of the District Road Works Manuals.

2. The second level of roadworks planning is done by the Districts who prepare mid-term and short-term plans for the implementation of roadworks. This planning is discussed in the District Road Works Manual **Volume 1 Manuals B**, **C** and **D**.

3. The third level of planning is done in the implementation of the works, i.e. site planning of the works. This is the work planning that shall be discussed in this section of this manual. There are a number of planning stages within this level of planning and some listed below:

   - The overall works planning for the entire roadworks project. i.e. **The Tenderer's Programme**. An example of this programme is given in **Section D4**, **Figure 1-D4**. The aim of this plan is to:

     i. work out the period within which the project must be completed.
     This period may either be fixed by the Engineer or it may be negotiated and agreed between the Engineer and the Contractor.

     ii. ensure that the specified contract period is adhered to. If the roadworks are to be done by a contractor (as opposed to force account), then the same programme will be part of the tender documents.

     iii. facilitates easy monitoring of progress on each activity and relate it to the overall completion or project period

   - The monthly planning must be prepared from the overall work programme. The aim of this plan is to give a clearer picture of the exact timing of resource requirements over the course of a month. The presence of this plan gives sufficient room to finalize arrangements for the required resources. A suggested format for this type of plan is shown in **Figure 1-D4**.

   - The daily and weekly planning details the exact quantities of work to be achieved each day in order to fulfill the overall programme. This level of planning allows the site personnel to plan in detail the resources to be applied on any given day in a particular week. A suggested format of this plan is shown in **Figure 1-D4**.

The topics discussed in **Sections D.1** to **D.3** below provide the backbone in the preparation of any of the work plans discussed under the third level of planning. The most important of these site plans is the work programme, which is the master plan on the basis of which all the other site plans are prepared.

D1 TASK RATES AND PRODUCTIVITY

General

In order to plan the works realistically it is necessary to have an idea of the realistic work outputs of the resources applied, namely, labour and equipment. It must be understood that the expected work outputs will generally vary with each set of prevailing circumstances. There are many factors which can affect the work outputs of both labour and equipment and these include climates, altitudes above sea level, local customs and laws, geology of the area, etc.

Therefore, it is more common to use **indicative** outputs for planning purposes. Indicative outputs are based on past experiences from similar projects within the country, region or from elsewhere. The indicative outputs are applied on site as a starting point and are gradually adjusted to suit the local conditions.

There are a number of work systems available for use with roadworks in general. The three most common ones are:

- Daywork system
- Piecework system
- Taskwork system

The three systems are defined in the **Table 1-D1** below, which also explains where and when each system may be applied.

TASK RATES

The task is the quantity of work that must be completed within a specific period of time. **The task rates can be defined as the quantity of work that an average person can complete in a fair day's work** (6 hours). Slow workers may complete the same quantity of work in as much as 7 hours whereas the stronger and faster workers may complete within 5 hours.

Most of the labour-based roadworks are carried out using the task rate system as it is an easy tool of managing the large numbers of workers involved. This system gives the worker one day's wage for each completed task.

The correct task rates can to be found by performing a **work study**. A work study involves observation of productivities of labourers under various conditions.

ADJUSTING TASKS

Having started off a project with the indicative task rates, the workers must be thoroughly observed in order to determine whether the tasks given are appropriate. The observer must ensure that the workers are working at a reasonable rate without unnecessary breaks.

If the majority of the workers have completed the daily task in less than 5 hours for more than 3 consecutive days, the task is clearly too small and it must be adjusted upwards. On the other hand, if the majority of the workers have not completed their daily task within 7.5 hours, the task is deemed excessive and may have to be reduced.

TABLE 1 - D1 WORK SYSTEMS

Work System	Description	Advantages and Disdvantages	Why and Where to Use the System
DAYWORK	• The workers are paid a fixed wage for every day of work.· • The worker is paid for attendance as opposed to output.	• It discourages workers who work harder because they get paid at the same rate as those who don't work as hard.· • The level of supervision is intense since workers have to be constantly monitored to ensure they are working.· • Administratively, it's easier to handle since workers are simply paid on the basis of being present or absent.	• This system is more suitable for highly skilled operations where a specialized workmanship is required.· • Also used where standard outputs are difficult to fix due to a large number of variables involved.· • Some suitable activities include boulder removal, peg cutting, water carrying and other supporting activities.
PIECEWORK	• The workers are paid for whatever the quantity of work they produce in a day.· • This allows workers to earn more than the standard rate by producing more.	• The administration is very difficult since each individual will earn a different wage based on production.· • The measuring is extremely intensive since it has to be done for each individual at the end of the working day.· • Higher productivity is achieved as hard working individuals take the opportunity to earn more.	• This system is more suitable for highly skilled operations where a specialized workmanship is required.· • Also used where standard outputs are difficult to fix due to a large number of variables involved.· Some suitable activities include masonry work, concrete work and gabions.
TASKWORK	• Each worker is given a fixed quantity of work to do for the day and gets paid for the day.· • The quantity of work to be done is standard for a given activity under the same conditions.	• The system can be unfair to workers or employers where task rates are over-estimated or under-estimated, respectively.· • Planning of the work and controlling the rate of production is simple since outputs are known precisely.· • A high output coupled with efficiency can be achieved since workers know their task and value the extra free time they can get if they work diligently.	• This system is more suitable for activities where standard outputs are easy to determine.· • Also used where standard outputs are difficult to fix due to a large number of variables involved.· • Most labour-based roadworks are easily done under this system..· • Some activities are better undertaken as group tasks as opposed to individual tasks.

INDICATIVE LABOUR TASK RATES

The table below shows the indicative task rates for labour.

TABLE 2 - D1 INDICATIVE LABOUR TASK RATES

TYPICAL LABOUR TASK RATES			
ACTIVITY	UNIT	TASK RATE RANGE	RECOMMENDED WORK SYSTEM
Setting out of alignment including cross sections, etc.	m	100	Daywork
Bush clearing including disposal of cuttings out of clearing width	m^2/wd	200 ~ 1000	Taskwork
Grubbing including disposal of grubbed materials out of clearing width	m^2/wd	150 ~ 300	Taskwork
Tree and stump removal (tree girth from 0.3m to 1.0m - measured at 1m above ground) including disposal of all vegetations out of clearing width	Nos.	2 ~ 5	Taskwork
Boulder removal (up to 1.5m girth) including disposal out of clearing width	m^3/wd	2 ~ 4	Daywork
Excavation excluding gravel excavation Rock excavation	m^3/wd	2.5 ~ 5.0 0.8	Taskwork Daywork
Slotting at specified intervals of 20m	m^3/wd	1.5 ~ 2.0	Taskwork
Ditching including throwing suitable material to the center of road	m^3/wd	2.5 ~ 3.5	Taskwork
Sloping and Backsloping including throwing suitable material to the center of road for camber formation	m^3/wd	3.0 ~ 4.0	Taskwork
Camber formation in formation activity to required camber slope	m^2/wd	180	Taskwork Group taskwork
Gravel excavation including stockpiling on the side of the pit	m^3/wd	2.5 ~ 3.5	Taskwork Group taskwork
Loading	m^3/wd	6 ~ 9	Taskwork Group taskwork
Unloading	m^3/wd	12 ~ 16	Taskwork Group taskwork
Spreading	m^3/wd	6 ~ 9	Taskwork Group taskwork
Combined unloading and spreading	m^3/wd	4 ~ 6	Taskwork Group taskwork
Wheelbarrow hauling excluding excavation	m^3/wd	1.8~7.6	Taskwork
Camber formation in gravelling activity to required camber slope	m^2/wd	140	Taskwork Group taskwork

To be continued on next page...

TABLE 2 - D1 INDICATIVE LABOUR TASK RATES *(CONT....)*

TYPICAL TASK RATES			
ACTIVITY	**UNIT**	**TASK RATE RANGE**	**RECOMMENDED WORK SYSTEM**
Watering by using watering cans and buckets for hauling	m^3/wd	4 ~ 6	Taskwork
Watering by water bowser with a water pump	trips	5 ~ 15	-
Compaction by hand rammers	m^2/wd	9	Taskwork
Compaction by roller (1 operator per roller required)	m^2/ rollerday	700	Taskwork
Scour check construction (excluding collection of stone, sticks)	Nos./wd	4 ~ 8	Taskwork
Stone collection within 200 m radius	m^3/wd	2 ~ 3	Taskwork
Stick collection within 200 m radius	Nos./wd	80 ~ 100	Taskwork
Installation of culverts (including excavation of trench and backfilling but excluding outlet drain, head walls and wing walls) - 600 mm pipe - 900 mm pipe - 1200 mm pipe	m/wd	 1.0 ~ 1.2 0.7 ~ 0.9 0.4 ~ 0.6	Taskwork Group taskwork
Head walls and wing walls construction including preparation of mortar	m^3/wd	1.0	Taskwork Group taskwork
Concrete works including mixing, hauling, placing and curing	m^3/wd	0.5 ~ 1.0	Taskwork Group taskwork
Wet stone masonry works including stone and mortar preparation but excluding stone collection	m^3/wd	0.7	Taskwork Group taskwork
Dry stone masonry works including preparation of stone but excluding stone collection	m^3/wd	2.5	Taskwork Group taskwork
Brick/Concrete block masonry works including mortar preparation	m^3/wd	1.0	Taskwork Group taskwork
Wet stone pitching including stone and mortar preparation but excluding stone collection	m^2/wd	4 ~ 8	Taskwork Group taskwork
Dry stone pitching including preparation of stone but excluding stone collection	m^2/wd	9	Taskwork Group taskwork
Gabion works including assembling of baskets and placing rock fill but excluding stone collection	m^3/wd	2.5	Taskwork Group taskwork

Note: A realistic task rate within the given ranged has to be decided upon based on actual site conditions

INDICATIVE PRODUCTIVITIES FOR HAULAGE AND COMPACTION

The figures below summarise the haulage and compaction productivities.

TABLE 3 - D1 WHEELBARROW HAULAGE PRODUCTIVITIES

WHEELBARROW HAULAGE RATES		Wheelbarrow Haulage Productivity by haulage distance per worker day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	Estimated volume of wheelbarrow is 40 litres/trip excluding excavation
	0~20m	190	7.6	170	6.8	130	5.2	
	21~40m	170	6.8	150	6.0	120	4.8	
	41~60m	150	6.0	135	5.4	100	4.0	
	61~80m	130	5.2	115	4.6	90	3.6	
	81~100m	110	4.4	100	4.0	75	3.0	
	101~120m	90	3.6	80	3.2	60	2.4	
	121~150m	65	2.6	55	2.2	45	1.8	

TABLE 4 - D1 HAULAGE USING 2 TRAILERS PER TRACTOR

MANUALLY LOADED TRACTOR/TRAILER		Equipment Haulage Productivity by two trailers per tractor combination per day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	Estimated volume of tractor-towed trailer is 3 m^3/trip
	0.0~0.5km	37	111	34	102	30	90	
	0.6~1.0km	30	90	26	78	21	63	
	1.1~1.5km	25	75	21	63	16	48	
	1.6~2.0km	21	63	18	54	13	39	
	2.1~2.5km	18	54	15	45	11	33	
	2.6~3.0km	16	48	13	39	10	30	
	3.1~3.5km	15	45	12	36	8	24	
	3.6~4.0km	13	39	10	30	7	21	
	4.1~4.5km	12	36	10	30	7	21	
	4.6~5.0km	11	33	9	27	6	18	

TABLE 5 - D1 HAULAGE USING 1 TRAILER PER TRACTOR

MANUALLY LOADED TRACTOR/TRAILER		Equipment Haulage Productivity by one trailer per tractor combination per day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	Estimeted volume of tractor-towed trailer is 3 m^3/trip
	0.0~0.5km	25	75	23	69	21	63	
	0.6~1.0km	21	63	19	57	16	48	
	1.1~1.5km	18	54	16	48	13	39	
	1.6~2.0km	16	48	14	42	11	33	
	2.1~2.5km	15	45	12	36	10	30	
	2.6~3.0km	13	39	11	33	8	24	
	3.1~3.5km	12	36	10	30	7	21	
	3.6~4.0km	11	33	9	27	7	21	
	4.1~4.5km	10	30	8	24	6	18	
	4.6~5.0km	10	30	8	24	6	18	

TABLE 6 - D1 HAULAGE USING A TIPPER TRUCK OR A FLAT BED TRUCK WHICH IS NOT ARTICULATED

MANUALLY LOADED TIPPER/TRUCK		Equipment Haulage Productivity by tipper/truck per day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	Estimeted volume of tipper/truck is 5 m^3/trip. The number of trips are applicable for all trucks with capacity of less than 10 m^3 but number of loaders will be increased.
	0 ~ 2 km	22	110	18	90	16	80	
	2 ~ 4 km	19	95	15	75	12	60	
	4 ~ 6 km	16	80	12	60	10	50	
	6 ~ 8 km	11	55	8	40	7	35	
	8 ~ 10 km	8	40	6	30	5	25	

TABLE 7 - D1 WATERING FOR COMPACTION

WATERING	Average Productivity Rates per day		Remarks
	Manual watering by labour	Using tractor-towed or motorized waterbowser	
Recommended output rates	4 ~ 6 m^3/wd	5 ~ 15 trips/bowsedays	Manual watering includes hauling water within source of 150 m. Bowser productivity depends on distance, road condition and demand of watering. Judgement of supervisor is required.

TABLE 8 - D1 COMPACTION USING VIBRATING ROLLERS

COMPACTION	Average Productivity Rate per day			Remarks
	Manual compaction by hand rammers	Equipment compaction by pedistrain rollers	Equipment compaction by ride-on rollers	
Recommended output rates	9 m^2/wd (max. thickness <150mm)	700 m^2/rollerday (max. thickness <200mm)	1400 m^2/rollerday (max. thickness <200mm)	Manual compaction with hand rammer is effective for side slopes and back filling of structure works where rollers cannot be used.

D2 RESOURCE ESTIMATION

With the indicative productivities discussed in **Section D1** above and the Bill of Quantities the labour, equipment and material resources required can be worked out.

The formula below is used for estimating the labour and equipment requirements:

$$\textbf{Labour or Equipment requirement} = \frac{\textbf{Quantity of work}}{\textbf{task rate (or output)}}$$

The material resources are also estimated based on the quantities in the Bill of Quantities. The quantities of materials required for the standard structures given as drawings in the contract document are shown in **Volume 4 Manual B**. The quantities of gravel are also given for each cross section type in **Section B2** of this manual.

D3 WORK ORGANISATION

Work organisation is the arrangement and distribution of the construction work among the gang of workers such that the best use is made of available resources (tools, labourers, materials and equipment).

The main tasks involved in work organisation include the following:

- Identifying the operations and activities involved and deciding the order in which the activities are carried out.
- Identifying the resources to do the work (labour, equipment and materials).
- Distributing labourers for each gang to work on specific activities and adjusting the gang size in each activity when necessary to achieve a **balanced rate of production**.
- Making available the materials required for the work at the times and locations that they are required.
- Planning for the equipment in such a way that maximum utilisation is obtained simultaneously with overall efficiency of the works.
- Motivating the labour force by using incentives such as task work.
- Giving clear and precise instructions to avoid misunderstandings.

Sequence of operations

Roadwork using labour-based techniques is divided into different **operations**. The works can be new construction, upgrading, rehabilitation and/or maintenance. An operation can be defined as a separate component of the works.

To ease planning and controlling of site work each operation is broken down into several practical and logical stages called **activities**. These activities must follow each other in a defined sequence. The operations and activities have to follow each other in a certain order because they depend on each other.

Normally, each activity is carried out by a distinct gang of labourers. The proper spacing from one operation to the next and the distribution of labourers working on each activity is therefore an important site management aspect.

An activity should follow the preceding one as closely as possible without causing interference or overcrowding. The distance between the first and last activity in road rehabilitation should preferably not exceed one kilometre for ease of supervision.

When starting on a new roadworks project, the number of workers on site will gradually increase as more activities are started.

Table 1- D3 shows a general view of the sequence of a normal rehabilitation road project. It should be noted that the construction sequence may change from contract to contract or from project to project depending on the scope of works involved in a particular project.

TABLE 1 - D3 SEQUENCE OF ROAD REHABILITATION OPERATIONS AND ACTIVITIES

OPERATION	ACTIVITY
SETTING OUT AND CLEARANCE WORKS	1. Setting out horizontal alignment
	2. Bush clearing
	3. Stripping and grubbing
	4. Tree and stump removal
	5. Boulder removal
EARTHWORKS (roadbed and formation)	6. Vertical alignment, detailed setting out, slotting/profiles
	7. Excavation/fill to level (including embankments), spreading and first compaction
	8. Ditching
	9. Spreading and second compaction
	10. Sloping
	11. Back sloping
	12. Camber formation and third compaction
	13. Reshape existing camber formation
DRAINAGE WORKS	14. Mitre drains
	15. Catchwater drains
	16. Construct scour checks
	17. Construction of culvert / drift / other structures
	18. Erosion control
GRAVELLING WORKS	19. Preparation of gravel quarry including access roads
	20. Excavate to stockpile
	21. Loading and hauling
	22. Spreading and final compaction
	23. Quarry rehabilitation/restoration
SUPPORT	24. Work at camp
	25. Water supply
	26. Emergency maintenance and maintenance before hand over
	27. General support as required

Gang balancing

Balancing is to divide the labour force between the roadworks activities in such a way that each activity can proceed without causing problems for other operations or activities. In order to achieve this, the activities must follow each other in the correct sequence at the same rate. The resources applied in each activity should allow the target output to be achieved. The target output is extracted from the updated work programme.

The number of workers on any activity will vary with the quantity of work of a particular stretch of road. As the quantities on each activity are not constant throughout the length of the road, the gang sizes for each activity will vary as the quantities change. If one activity moves slowly due to poor gang balancing, it will slow down all the other activities that come after it in the sequence. This will lead to inefficiency in that some gangs will be redundant since there will be no space for them to work and the equipment will be under-utilised. That is why gang balancing is an on-going task for the daily planning on site.

D4 WORK PROGRAMMING

Work programming involves breaking down the works into all the operations of the Bill of Quantities and showing their timing over the contract period in the form of a bar chart. Also shown on the work programme are the resources, i.e. labour, equipment and materials (*optional*) that are going to be applied as the work progresses over the contract period.

The basic steps for programming the works are listed below:

1. Break the works down into operations and/or activities for which quantities can be easily allocated. The operation is the largest group of activities that can be presented in the programme; however, it is easier and more desirable to break down the entire works further into activities.
2. Divide the quantities of each activity by the task rate and/or output rates of the applied resources (labour, equipment and materials) in order to calculate the total resource inputs. Alternatively, simply add up the productivities of each type of resource for each BOQ item as calculated in the unit rate analysis sheets (**Volume 2 Manual A3**). In this case, the total resource inputs will be equal to the quantity multiplied by the productivity.
3. Work out the correct sequence of the operations/activities and, by trial and error, fit them into the bar chart in such a manner that all of the following conditions are fulfilled:
   - The total worker days per week increase gradually, due to the staggered start of the activities, to a fairly constant peak. The peak persists for the duration of the bulk of the works and gradually tapers out at the end as activities are completed.

     It is important that this condition is observed in order to plan adequately for recruitments and redundancies.

   At this stage, the total **daily** worker days may not be at an exact constant peak, though it is important that the peak figures do not vary by more than 10%. However, the **weekly** worker day peaks **must** be at a constant peak at this stage. This is done by pushing forward and/or backward some of the daily worker days for some of the non-critical activities.

   The exact balancing of the daily worker days will be done during the preparation of the monthly, weekly and daily site plans in such a manner that:

   - The resources to be utilised in each week do not exceed the practically available resources.
   - The applied equipment must be utilised as efficiently as possible. Equipment is the most critical resource in the works and it must always be fully utilised at all times in order to keep the costs down.
   - All the activities are within the time limit of the contract period as agreed between the **Contractor** and the **Employer**.
   - The activities must follow in a logical sequence and operations must be staggered at the start and end.
4. It is easier to start off by working out the daily programme and bar chart in order to get the correct logic. Once the daily programme has been refined by resource levelling as explained above, then the weekly programme **Figure 1-D4** can be drawn up from the daily programme.

5. In the first instance, the Contractor shall present the bar chart to the Engineer in the form shown in **Figure 1-D4** (i.e. the weekly format). However, for the purposes of clarification, the Engineer may ask for expanded programs on certain selected items. *(For example, the engineer may request the contractor to further subdivide/expand the BOQ item 5.2 into a number of activities and present it as a separate bar chart).* This will allow the Engineer to clearly see how the Contractor plans to do excavation, stockpiling, loading and hauling, off-loading and spreading, watering and compaction of gravel.

The importance of a realistic and well-presented work programme cannot be over-emphasised as it will assist both the Employer and the Contractor (and his/her site supervisory staff) in the implementation of the job. The Contractor will use the programme to work out his/her cash flow, bid for the job as well as monitoring the efficiency and profitability during implementation. The Client will use the programme for monitoring and supervising the contractor and assist him/her in planning his/her site visits.

However, a work programme is not prepared as a one-off document at the bidding stage, but it should be continuously updated and revised. It will normally be necessary to update a work programme throughout the contract at intervals not longer than the period stated in the **Contract Data**.

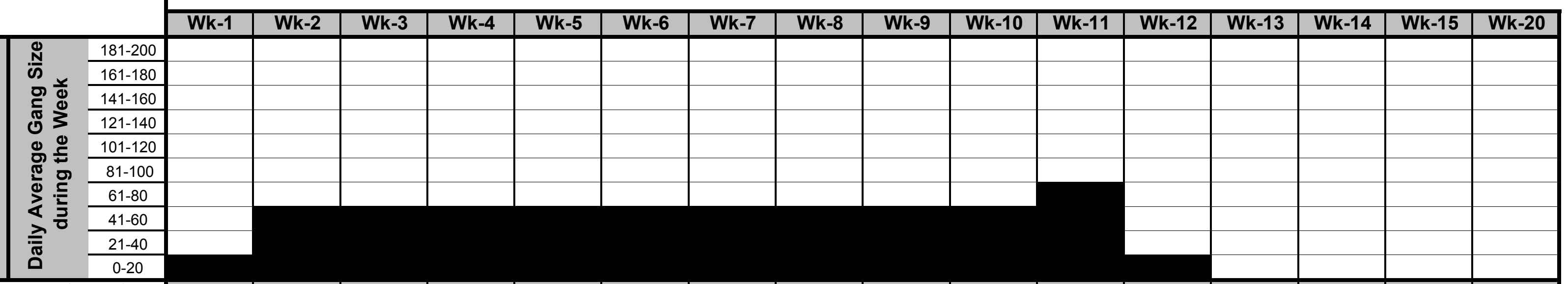
The **update of the programme** should show the actual progress achieved on each work item and the effect of the progress achieved on the timing of the remaining activities including any changes to the sequence of the activities. A revision of the work programme should be submitted to the District Engineer for approval.

A **revised programme** is to show the effects of variations and compensation events.

It is suggested that the format in **Figure 1-D4** be adopted for monthly work programmes. Information can be extracted from this format to detail daily site plans combined with daily reports as shown in the chart of **Table 3-H2**. The daily plans and reports can be combined to monitor progress that can be expressed cumulatively in form of bar charts drawn next to the plan for each work activity.

BoQ Item	Activity	Unit	Qty	Productivity	Total (WDs)	Gang Size	Time (days)	Wk-1	Wk-2	Wk-3	Wk-4	Wk-5	Wk-6	Wk-7	Wk-8	Wk-9	Wk-10	Wk-11	Wk-12	Wk-13	Wk-14	Wk-15	Wk-16
B1	**SITE PREPARATORY WORKS**																						
B1.1	Construction of access roads to quarry sites including maintenance throughout the work							10															
B1.2	Construction of detours including maintenance throughout the working period																						
B2	**SETTING OUT AND SITE CLEARING WORKS**																						
B2.1	(Re) Establishment of road alignment and setting out of road Works	m																					
B2.2	Clear site of all grass, bushes and boulders (up to 1.5m maximum girth) and Grub all roa	m																					
a	*Bush clearing*																						
b	*Stripping and Grubbing*																						
c	*Boulder removal*																						
B2.3	Cut and remove from site trees (up to 1 m girth), including removal of stumps and roots.	No.																					
B3	**EARTH WORKS**																						
B3.1.1	Reshaping of existing road formation including watering and compaction	m	6,730	0.05	337	10	33.7	10	10	10	10	10	10	10	10								
B3.1.2	Opening of / re-excavation of side, mitre, catch water and other specified drains																						
B3.1.3	Opening of culverts																						
B3.2.1	Excavation to level	m^3																					
B3.2.2	Excavation of side, mitre, catch water and other specified drains	m																					
a	Ditching																						
b	Sloping																						
c	Excavation Mitre Drains, Catchwater drains																						
B3.2.3	Form, water and compact road bed	m																					
B3.3.1	Preparation of borrow pit(s) consisting of clearing from vegetation and removing topsoil	m^2																					
B3.3.2	Excavation, hauling, placing, watering and compaction of approved fill material in embar	m^3																					
B3.4	Excavation of Rock																						
B4	**DRAINAGE WORKS**																						
B4.1	Provide and install scour checks	No.																					
B4.2	Excavation of foundation for drainage structures																						
B4.3	Supply and install concrete culvert pipe rings	m																					
B4.4	Supply and install steel culvert pipe rings																						
B4.5	Demolish existing structures and cart away debris																						
B4.6	Provide material and build cement bound masonry work in	m^3																					
B4.7	Provide stones and build dry stone masonry walls																						
B4.8	Provide, erect and remove formwork for concrete																						
B4.9	Provide and fix steel reinforcement																						
B4.10	Provide, place and compact hardcore foundation layer for structures																						
B4.11	Provide, cast and cure concrete																						
B4.12	Provide gabion baskets and stones, place and fill baskets																						
B4.13	Provide material and build grouted stone pitching, 150 mm thickness																						
B4.14	Provide selected material and backfill structures	m^3																					
B4.15	Excavate water diversions and/or construct barriers																						
B4.16	Clear swamps for structures, 50m upstream from inlet and 100m downstream from outle																						
B4.17	Other drainage erosion protection works as directed by the Engineer (Provisional Item																						
B5	**GRAVELLING AND COMPLETION WORKS**																						
B5.1	Preparation of quarry site(s) consisting of clearing vegetation and removing topsoil	m^2	2,505	0.1743	437	11	39.7																
B5.2	Excavate gravel, remove boulders, stockpile, load, haul, offload, spread, water and com	m	6,730			48	49.0		48	48	48	48	48	48	48	48	48	48					
a	*Excavation and stockpile gravel*	m^3	3,634	0.4	1,454	32.00	45.0																
b	*Loading and offloading gravel*	m^3	3,634	0.125	454	10.00	49.0																
c	*Spreading, watering and compaction*	m^3	3,634	0.083333333	303	7.00	49.0																
B5.3	Restoration of site(s), quarries and borrow pits	m^2	3,841			15	7.0										15	15					
B6	**PRELIMINARY AND GENERAL ITEMS**																						
B6.1	Mobilisation and Demobilisation																						
B6.5	Maintenance of the Whole of the Works																						
B6.7	Site Meetings with Local Communities including HIV/AIDS awareness																						
				Total WD:		**Total GangSize:**		20	58	58	58	58	58	58	58	48	48	63	15	0	0	0	0

Labour Resource Utilization Chart



	Wk-1	Wk-2	Wk-3	Wk-4	Wk-5	Wk-6	Wk-7	Wk-8	Wk-9	Wk-10	Wk-11	Wk-12	Wk-13	Wk-14	Wk-15	Wk-20
Gang Size:	20	58	58	58	58	58	58	58	48	48	63	15	0	0	0	0

Equipment Utilization Chart

Equipment Utilization	Number Needed	Total No. of Days	Rental Rate		Wk-1	Wk-2	Wk-3	Wk-4	Wk-5	Wk-6	Wk-7	Wk-8	Wk-9	Wk-10	Wk-11	Wk-12	Wk-13	Wk-14	Wk-15	Wk-20
Tractor	2				1	2	2	2	2	2	2	2	2	2	2	1				
Towed Trailer	3				1	3	3	3	3	3	3	3	3	3	3	1				
Water Bowser	1				1	1	1	1	1	1	1	1	1	1	1	1				
Towed Grader	0																			
P V Roller	2				1	2	2	2	2	2	2	2	2	2	2					
Tipper	0																			
Truck (non-tipping)	0																			
Water pump	1				1	1	1	1	1	1	1	1	1	1	1	1				

Update Programme Number .... Date and Signed by Contractor . . . . Date and Approved by Engineer . . . .

Contract Reference Number - ....

SCHEDULE 1 - PROGRAMME

Date .... / .... / 20 ....

BoQ Item	Activity	Qty	Productivity	Total (WDs)	Gang Size	Time (days)	Wk-1	Wk-2	Wk-3	Wk-4	Wk-5	Wk-6	Wk-7	Wk-8	Wk-9	Wk-10	Wk-11	Wk-12	Wk-13	Wk-14	Wk-15	Wk-16	Wk-17	Wk-18	Wk-19	Wk-20
			Total WD:		Total Gang Size:																					

Labour Resource Utilization Chart	Daily Average Gang Size for the Week	Wk-1	Wk-2	Wk-3	Wk-4	Wk-5	Wk-6	Wk-7	Wk-8	Wk-9	Wk-10	Wk-11	Wk-12	Wk-13	Wk-14	Wk-15	Wk-16	Wk-17	Wk-18	Wk-19	Wk-20
	181-200																				
	161-180																				
	141-160																				
	121-140																				
	101-120																				
	81-100																				
	61-80																				
	41-60																				
	21-40																				
	0-20																				
	Gang Size:																				

Equipment Utilization Chart	Equipment Utilization	Number Needed	Total No. of Days	Rental Rate		Wk-1	Wk-2	Wk-3	Wk-4	Wk-5	Wk-6	Wk-7	Wk-8	Wk-9	Wk-10	Wk-11	Wk-12	Wk-13	Wk-14	Wk-15	Wk-16	Wk-17	Wk-18	Wk-19	Wk-20
	Tractor																								
	Towed Trailer																								
	Water Bowser																								
	Towed Grader																								
	P V Roller																								

Update Programme Number ....

Date and Signed by Contractor . . . .

Date and Approved by Engineer . . . .

Section E

Earth Road Works

Section E
Earth Road Works

EARTH ROAD WORKS

Most of the District Roads are Gravelled Roads. The rehabilitation of unpaved roads (Gravelled Roads) is normally carried out in two stages as follows:

STAGE I - EARTH ROADWORKS

This stage involves earthworks for provision of roadbed or embarkments in poorly drained areas, drainage system including the construction of structures for water crossings. And any structure works will be considered as seperate operation. (refer to **Section B** and **Section E4** of this manual and also to **Volume 4 Manual B**). The drainage structures are described fully in the Standard Design Manual (**Volume 4 Manual B**). Only side drains are discussed fully in this manual.

STAGE II - SURFACING

After constructing the earth road, for it to be all weather road, it is necessary to provide a surfacing layer of Gravel, Bitumen or other surfacing material.

Gravel surfacing to provide all weather condition is carried out as a separate operation in view of the different skills and resources required. Surfacing is normally done immediately after earth road camber has been formed and compacted.

However, due to various reasons, gravelling may sometimes be done long after the camber formation. Gravelling may also be performed during a periodic maintenance operation. In both cases, reshaping may have to be carried out first to bring the earth road camber back to the desired shape before gravelling begins. Surfacing is described in **Section F** of this manual.

In both stages, most of the activities can be done by labour, except haulage of gravel over longer distances and compaction which may require equipment.

In order to achieve satisfactory workmanship and simplify supervision, the road improvement process for both Earth Road and Surfacing is broken down into a series of simple work operations and activities as described in **Section D3** of this manual. This section of the manual will describe the methods to undertake the different activities involved in the works.

Section E1

Setting Out

Section E2 : Site Clearing

Section E3 : Roadbed and Formation

Section E4 : Structures

Section E1
Setting Out

SETTING OUT

E1.1 SETTING OUT PROCEDURE

Surveying for setting out of labour-based roadworks depends on the nature of work. New constructions require establishment of new alignments while improvement or rehabilitation of existing roads may only require minor alignment corrections. The choice of alignment has great implications on the costs and method of construction.

PRELIMINARY SETTING OUT

A preliminary route alignment must be selected by the Engineer before procurement for the purpose of defining the Works in the contract documentation and to prepare the Bill of Quantities.

In rehabilitation or improvement works re-alignment shall only be done where the following situations are encountered:

- There is need for constructing a new major structure
- The existing ground conditions are too poor to allow economical construction
- The technical standards requirements to which the road is being upgraded are not fulfilled.

The preliminary route selection for realignment and new construction shall involve staking of the intended road centerline with pegs (wooden if possible) at 50 metres intervals. The pegs must be securely driven down into the ground in such a way that the tips are left exposed for painting and numbering for ease of identification.

In performing the preliminary road alignment assessment, where a new alignment or a realignment is required, the Engineer shall choose a route in such a way that:

- Objects and poor ground conditions such as swamps, boulders, unstable soils, trees, etc. are avoided.
- There is minimum need for heavy earthworks. The road centerline should be carefully located to favour cutting of material rather than filling. This strategy will help to reduce the risk of the fill material sliding down the slope and the need of costly equipment compaction.
- Properties that will attract high compensation are avoided.
- Features that will increase maintenance costs and vehicle operating costs (e.g. steep gradients, sharp curves) are avoided.
- The improvement of road drainage not unduly expensive.
- The technical standards requirements can be easily achieved i.e. the geometry of the road.

DETAILED SETTING OUT

The detailed setting out is carried out by the Contractor during the implementation stage of the road project. The detailed setting out is not done arbitrarily but is guided by the preliminary setting out. The detailed setting out involves the setting out of the entire centerline (horizontal and vertical alignment), chainage reference pegs, cross sections and the setting out for all the activities.

Detailed setting out procedures are described in this manual while setting out methods for specific structures and erosion protection works are described in the **Standard Design Manual** (**Volume 4 Manual B**).

E1.2 SETTING OUT TOOLS

Basic aids and instruments for setting out labour-based roadworks are:

- Reference pegs
- Tape measure
- String and line level
- Spirit level
- Ranging rods
- Profile boards
- Boning rods
- Dumpy level

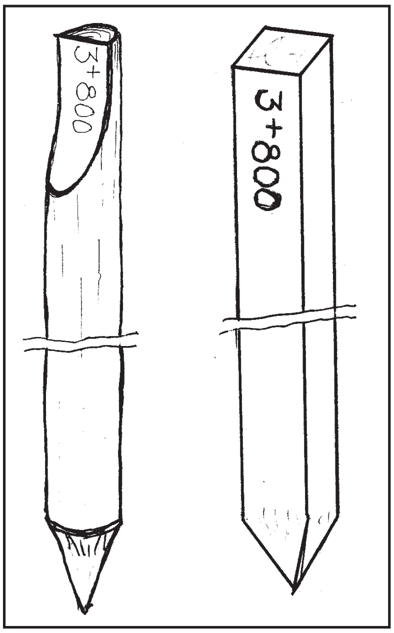
REFERENCE AND SURVEY PEGS

Reference pegs are made of wood having a length of approximately 40cm with either a 5cm diameter round cross section or a 5cm square cross section. The top part of the peg should be painted so that it stays visible. On one side (i.e. the lower side) the peg should be sharpened to ease driving into the ground.

Reference pegs are used for marking both the alignment and the cross sections. Road chainage is marked on the reference pegs (two per cross section, one on each side of the road at 20m intervals along the road) using waterproof marker pens. The reference pegs should be placed at the limits of the bush clearing widths and kept in place until all roadworks are completed.

Survey pegs are used to demarcate the road centreline, the edges of the carriageway, shoulders, side drains and/or to show the future levels of base course and gravel surfacing.

FIGURE 1 - E1.2: REFERENCE PEGS

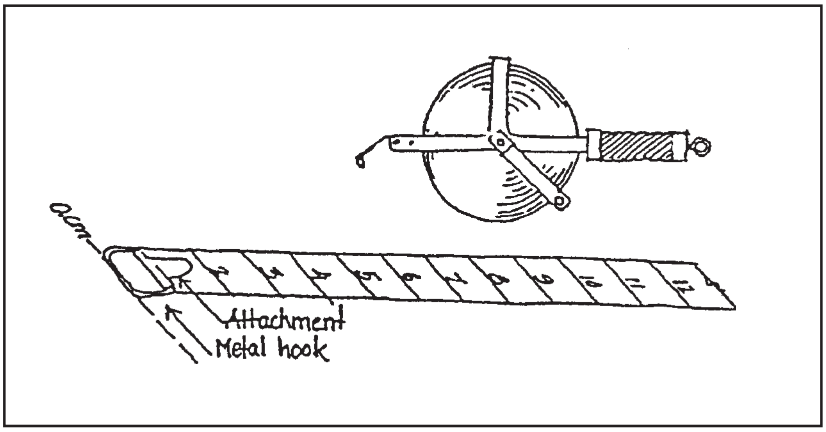


TAPE MEASURE

Tape measures are used for measuring distances between any two points.

The common lengths of tape measures used for setting out are 5m and 30m. The tapes are made of steel, fiberglass or linen.

FIGURE 2 - E1.2: TAPE MEASURE

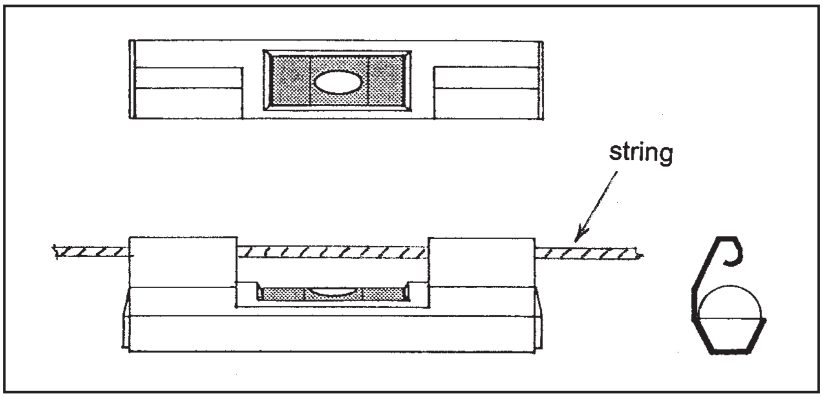


LINE LEVEL AND STRING

Line levels are used for setting levels or transferring levels between two points. An operator and two assistants are needed to use this arrangement.

A line level is a small spirit level about 80mm long with a hook/ hanger arrangement at each end to suspend it from a string or fishing line (2mm thickness). The line level has hooks on each end that are used for hooking it onto the string.

FIGURE 3 - E1.2: LINE LEVEL



SPIRIT LEVEL

Spirit levels are used for checking levels between short distances. Various lengths of spirit level exist and each length is suitable for a specific nature of work. The 1.2 metres long spirit level is suitable for use with camber boards. Shorter ones are commonly used in masonry or building work.

RANGING RODS

Ranging rods are long poles (usually 2 metres in length and made of metal, wood or hard plastic) with a pointed metal end for ease of driving into the ground. For clear visibility they are painted with alternating red and white colours at various intervals depending on the manufacturer. A standard interval of 0.2 metres for the alternating red and white colours is recommended.

A very useful tool to be used with ranging rods is a sliding hammer (or hole hammer) with a weighted head that fits over the ranging rod, used to drive the ranging rods into the ground.

FIGURE 4 - E1.2: RANGING RODS

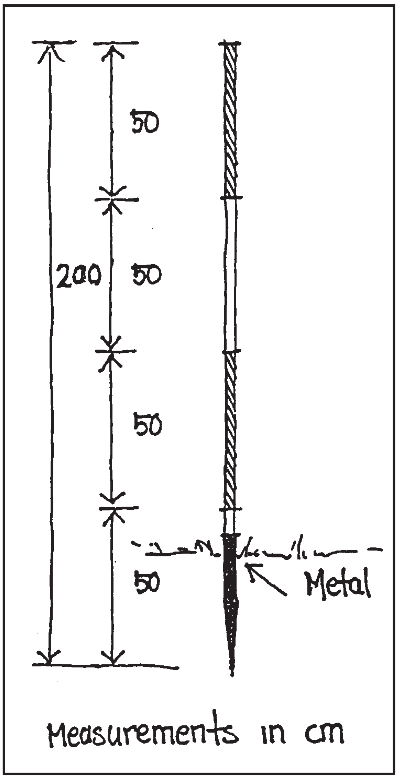
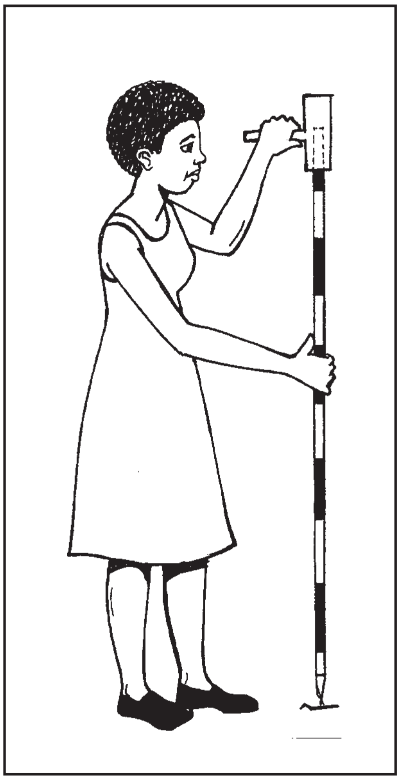


FIGURE 5 - E1.2: HOLE HAMMER



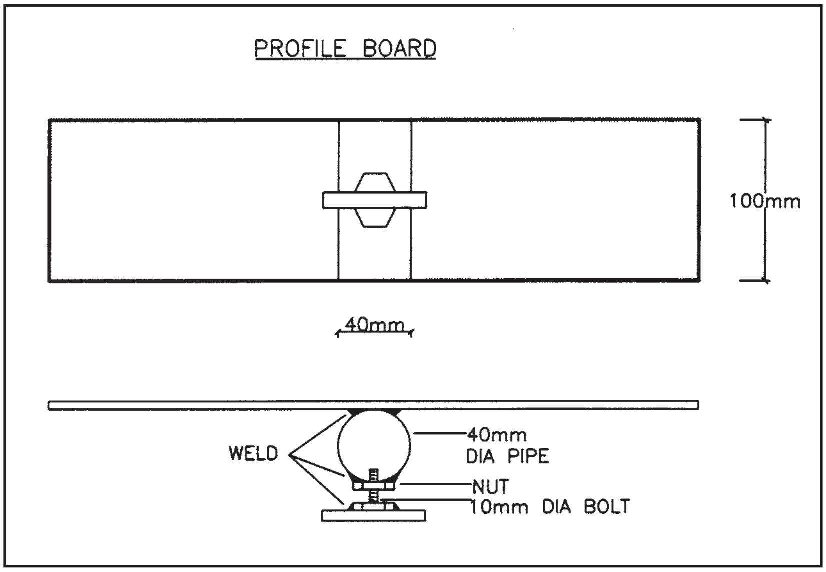
Ranging rods are used to set out straight lines and to support profile boards on both straight and curved sections of the road. They are also used with line level for setting levels.

PROFILE BOARDS

Profile boards are used together with ranging rods. They are 3mm thick steel plates (40cm x 10cm) welded to a short piece of 40mm diameter metal pipe equipped with a thumb screw mechanism. They can be fixed or slid up and down the ranging rod by tightening and loosening the screw. The board is painted on both faces with white enamel paint for easy visibility.

Profile boards are used for setting out levels of cross sections and vertical alignment of road.

FIGURE 6 - E1.2: PROFILE BOARDS

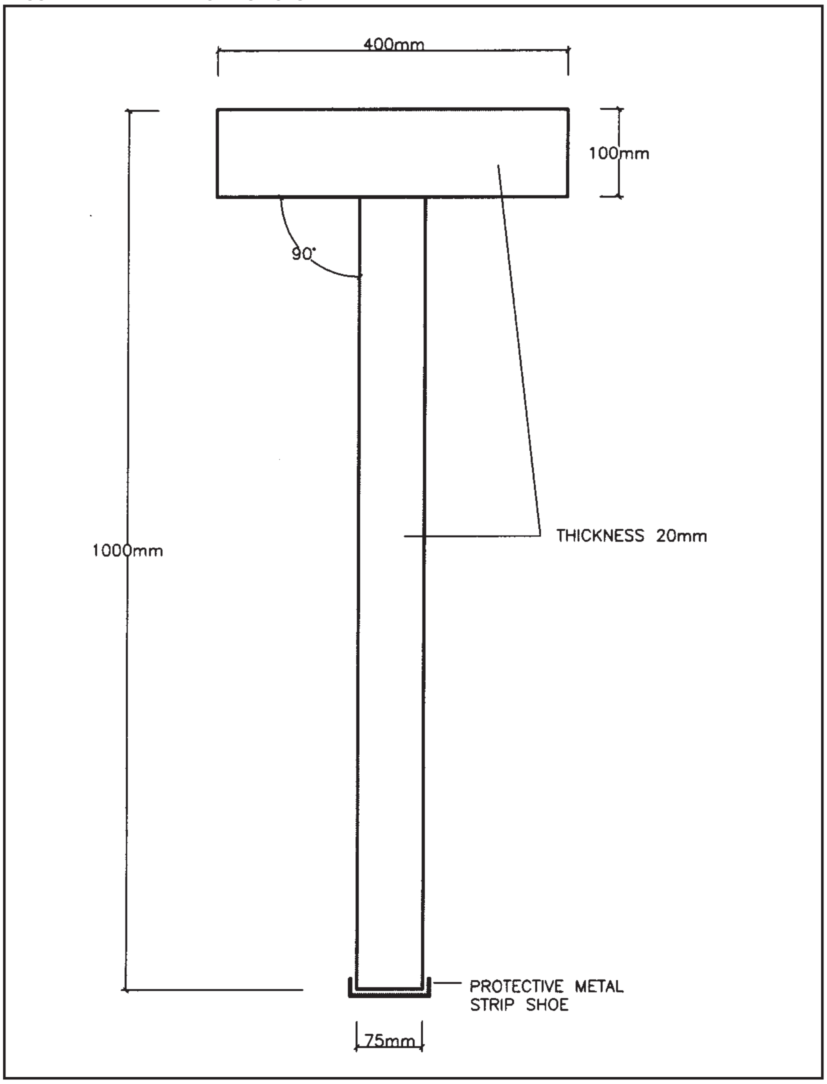


BONING RODS

Boning rods are made of two seasoned wooden lathes, nailed to each other at right angles in the shape of the letter "**T**". The boning rods should have a uniform height of 1 metre.

Boning rods are used for checking levels between two established points.

FIGURE 7 - E1.2: BONING RODS



DUMPY LEVEL

Dumpy level is precision equipment equipped with a telescope and tripod as a stand. There are several types on the market. It is used in combination with levelling staffs.

Dumpy levels are used to set out levels where high degrees of accuracy are required. Levels can also be transferred over longer distances (as much as 200 to 300 metres) because of the telescope.

E1.3 BASIC SETTING OUT SKILLS

This section describes some basic skills or techniques that will be encountered in setting out of road construction or maintenance works.

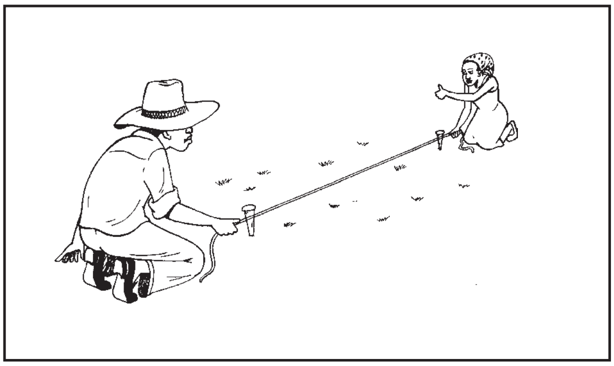
SETTING OUT STRAIGHT LINES

Setting out straight lines using strings

This method is preferred for intermediate points between two ends on a short straight not exceeding 25m. The procedure for this is outlined below:

1. Fix pegs on the two end points which have been identified on the straight line.
2. Stretch a string and tie it firmly to the two pegs in such a way that the string is not touching the ground. The string must be thoroughly stretched to remove any slack that might distort the straight line. The string must also be completely free throughout its stretched length.
3. All the desired points along the straight line can be marked by fixing pegs along the string line.

FIGURE 1 - E1.3: SETTING OUT A STRAIGHT LINE USING STRINGS



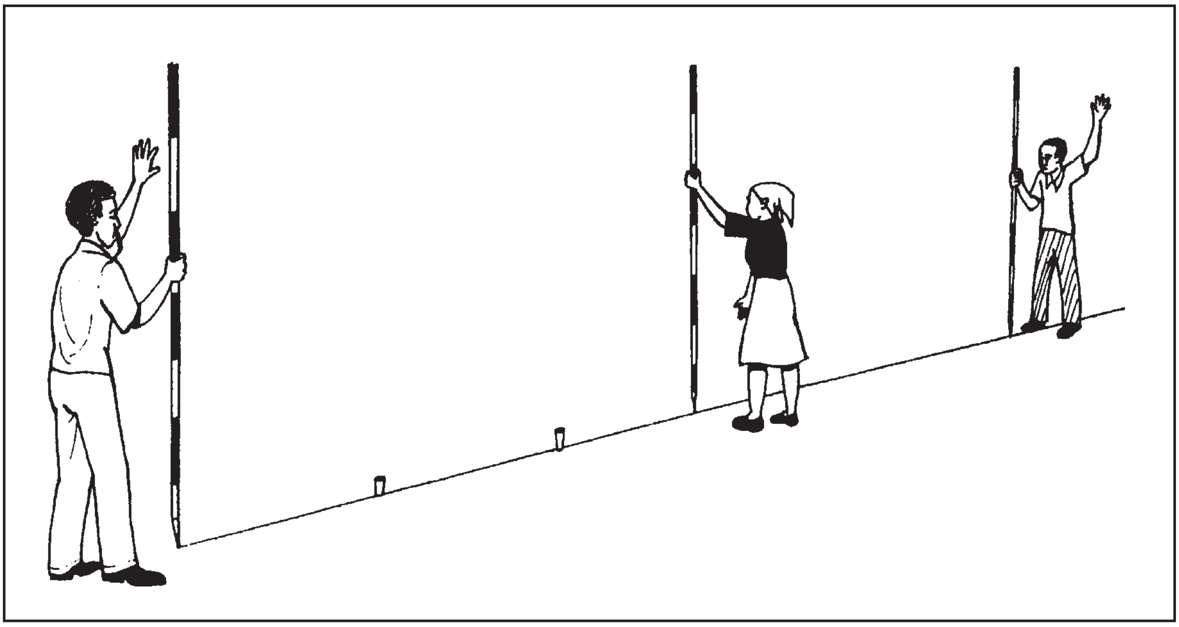
Setting out straight lines using ranging rods

The procedure outlined below is for setting out straight lines when two points on the straight have been fixed.

1. Fix ranging rods on the two points which have been identified on the straight. Ensure that both the rods are fixed vertically upright. For comfortable sighting, the distance between the two rods should not exceed 120m.
2. One worker who will sight through the rods shall position himself/herself at one of the ranging rods in such a way that he/she has a clear view of both rods simultaneously. A second worker takes his/her position at the other fixed rod.
3. A third worker with a third ranging rod, the traveler, will be directed by the worker who is sighting to fix other points on the straight line. The traveler will fix points either between the two fixed ranging rods or outside of them.
4. To fix a point between the two fixed ranging rods, the traveler rod is placed at a point between the two fixed rods.

   To fix a point outside the two fixed ranging rods, the traveler rod is placed at a point outside the two fixed rods. The distance between the sighting rod and the traveler rod should not exceed 120m.
5. The worker on one of the fixed ranging rods sights through the three rods and directs the worker holding the traveler until all three ranging rods are in line.
6. Fix pegs on all identified points.

FIGURE 2 - E1.3: SETTING OUT A STRAIGHT LINE USING RANGING RODS



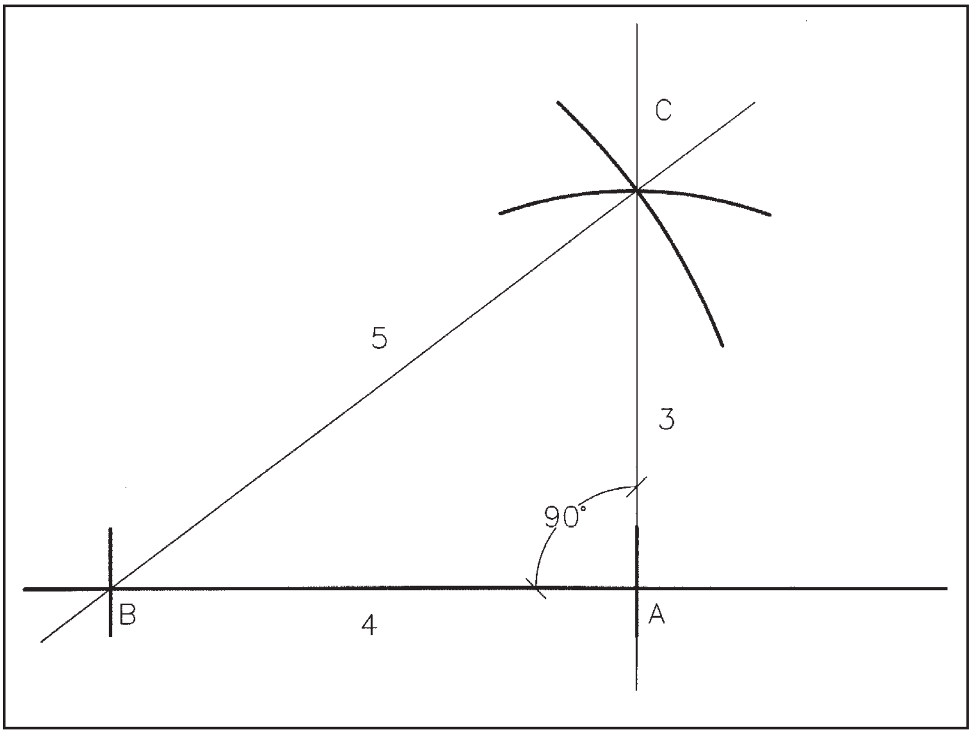
SETTING OUT ANGLES

Setting out 90 degree angles

The procedure for using the 3-4-5 method

1. Measure out a length AB of 4m along the straight from point A where the 90° angle is required. Drive in pegs at points A and B.
2. From point A, draw an arc of radius 3m on the appropriate side of line AB. Practically, this can be done by attaching a peg at the end of a fully stretched 3m string fixed at point A and using the attached peg to draw the arc.
3. From B draw an arc of radius 5m as in step 2 above until it intersects with the arc in step 2. The arcs will meet at 2 points on either side of the line AB. (see **Figure 3-E1.3**) shown as point C.
5. The angle formed at point A between lines AB and AC is 90°.

FIGURE 3 - E1.3: SETTING OUT RIGHT ANGLE BY 3-4-5 METHOD



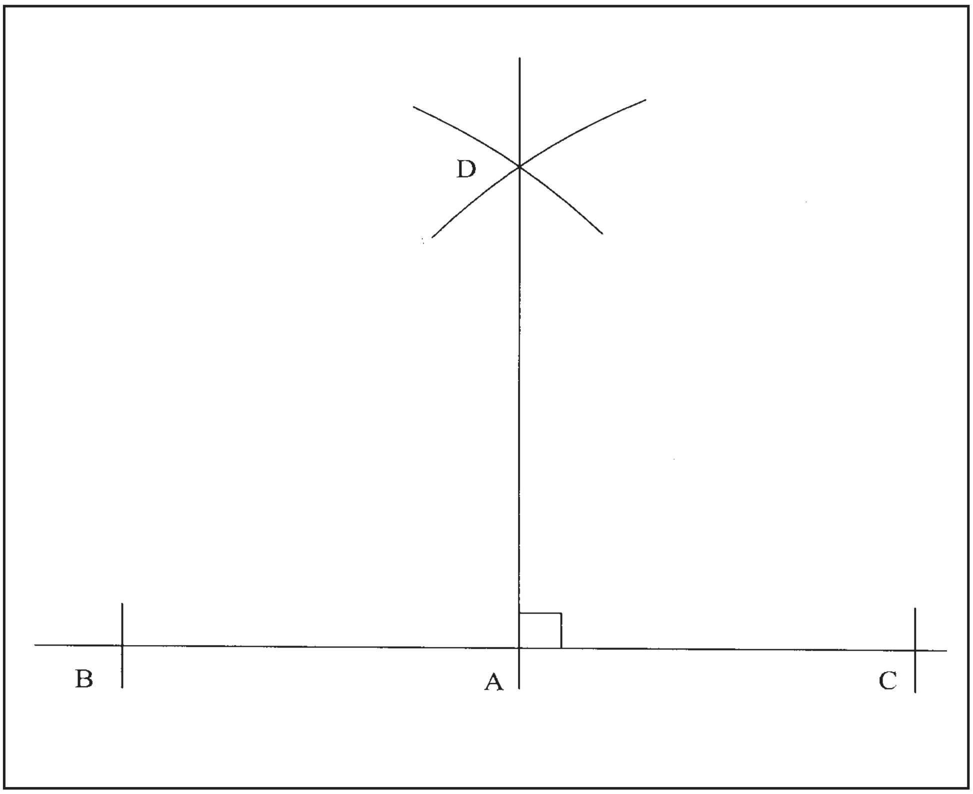
Setting out 90 degree angles

The bisecting method

This method is faster, easier and more accurate and involves the following procedure:

1. Obtain and mark point A at the exact middle of a string of 5 ~ 10 metres with a marker or a knot and stretch it into a straight.
2. Mark points B and C at the ends of the straight through A using pegs.
3. Holding one end of the string at peg B, draw an arc using the full length of the string.
4. Holding one end of the string at peg C, follow step 4 above until the two arcs intersect at point D.
5. The line AD is at right angles to the line BC.
6. Note that the same method is used to set out right angles at specific points along a curve.

FIGURE 4 - E1.3: SETTING OUT RIGHT ANGLES USING THE BISECTING METHOD



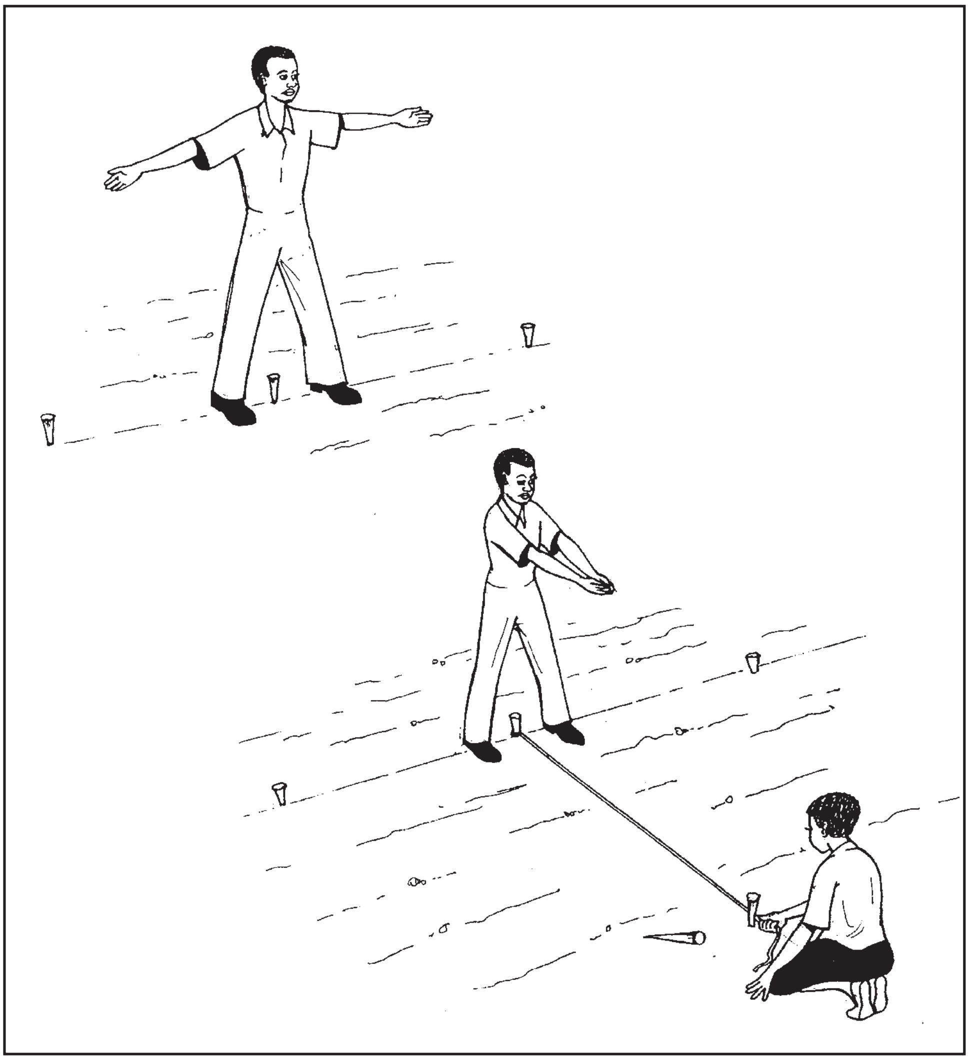
Setting out 90 degree angle

The hand clapping method

This method is the least accurate of the methods used to set out right angles. It must, therefore, only be used for setting out in situations where a high level of accuracy is not necessary. An example of such a situation would be in the setting out of quarries. The procedure for this method is outlined below:

1. Stand over the peg from which the right angle needs to be set out, with the feet and arms stretched out along the straight.
2. While looking straight ahead, swing the arms slowly to come together in front of you as if you are going to clap your hands.
3. When the hands meet in front of your eyes, sight the offset peg using your hands as a guide.

FIGURE 5 - E1.3: SETTING OUT RIGHT ANGLES USING THE HAND CLAPPING METHOD



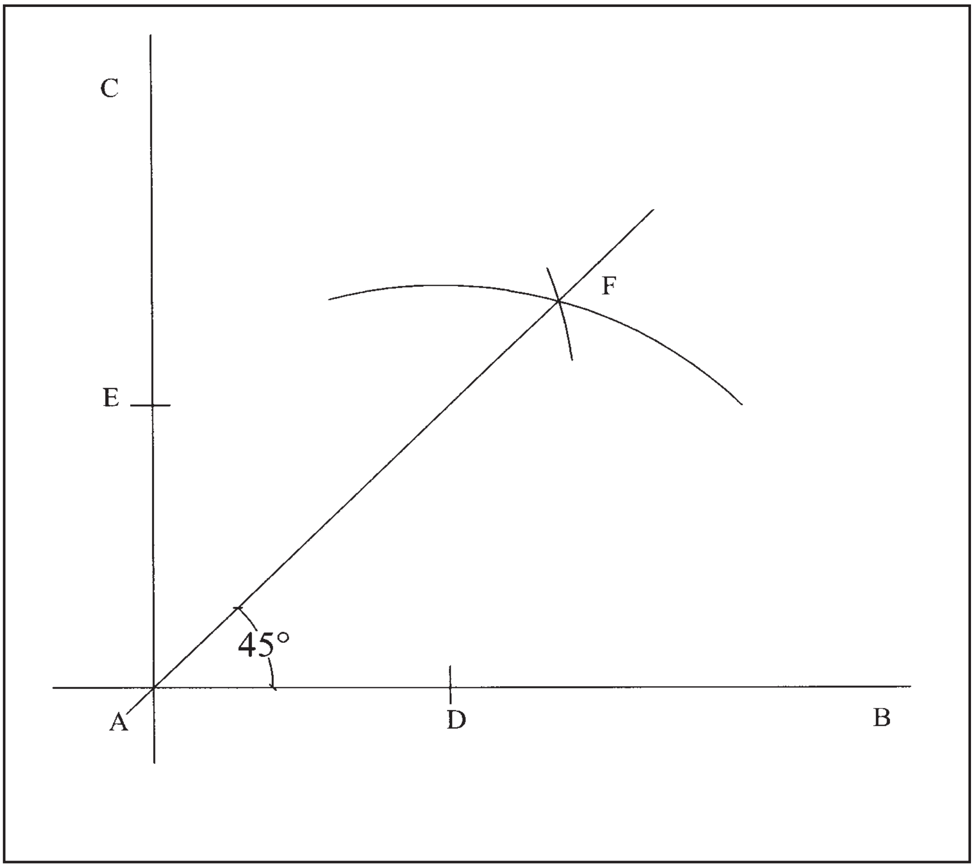
Setting out 45° angle

Bisecting method

The following procedure is involved in setting out a 45° angle:

1. Set out a right angle using any of the methods outlined for right angles.
2. Measure equal distances from the point A along AB and AC. Mark these two points as D and E respectively.
3. From points D and E draw arcs of the same length to intersect at point F. The line AF will be at 45° to line AB.

FIGURE 6 - E1.3: SETTING OUT 45° ANGLES USING THE BISECTING METHOD

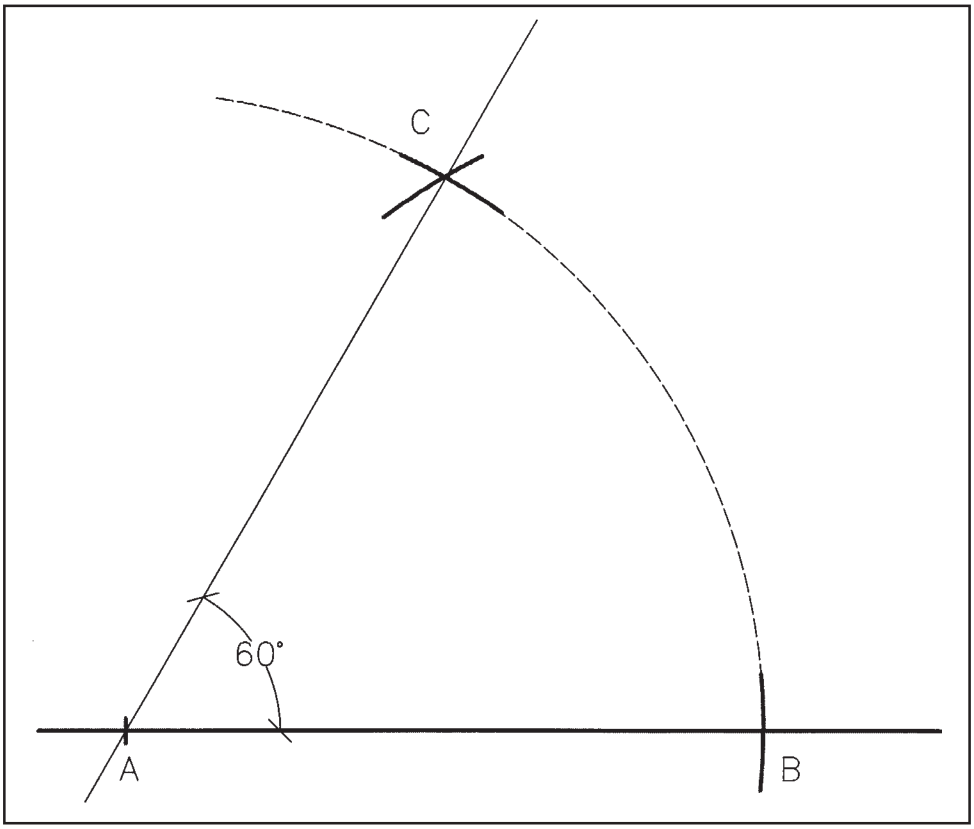


Setting out a 60° angle

The intersecting arc method

1. From point A, where the 60° angle is required, draw an arc of a specific radius through point B on the original straight.
2. From point B, using the same radius as the length AB, draw another arc to intersect the first arc at point C.
3. The line AC is at 60° to the line AB.

FIGURE 7 - E1.3: SETTING OUT A 60° ANGLE USING THE INTERSECTING ARC

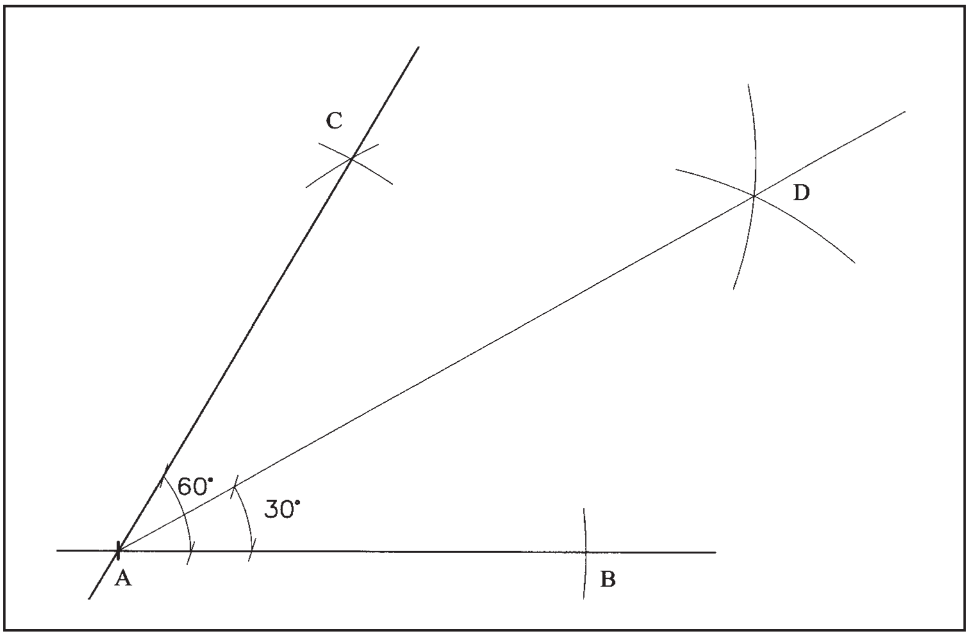


Setting out a 30º angle

The bisecting method

1. Set out a 60º angle as described in the method above.
2. Using the bisecting method described above, bisect the 60º angle to make a 30º angle.

FIGURE 8 - E1.3: SETTING OUT A 30⁰ ANGLE USING THE BISECTING METHOD



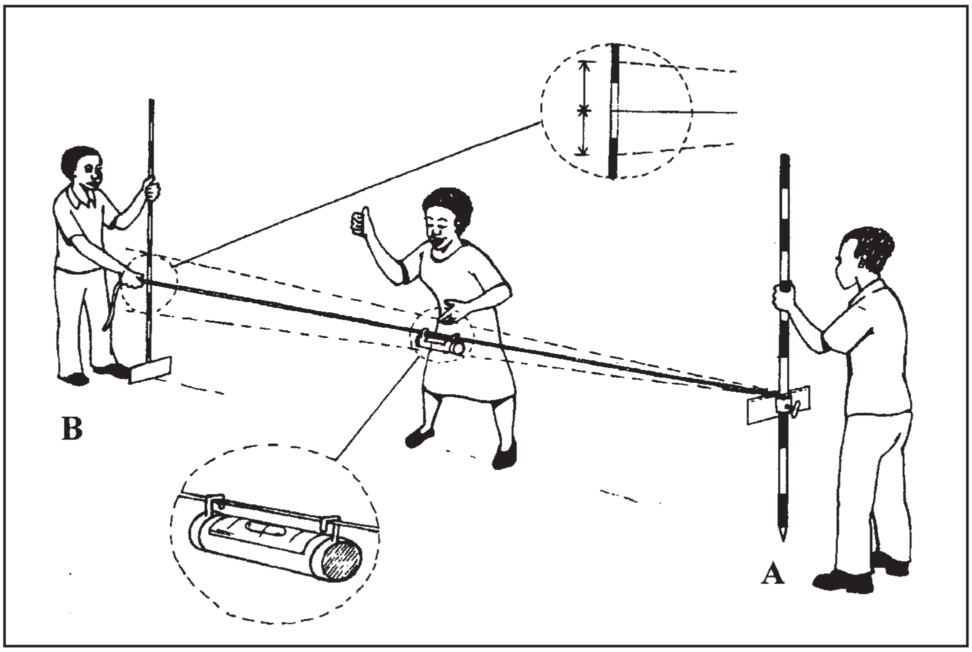
SETTING OUT LEVELS

Checking accuracy of a line level

The accuracy of line levels should not be taken for granted. Due to their small size, line levels are prone to many damages during their lifetime and, therefore, the line level used should be regularly checked for accuracy in the field. The procedure for checking the accuracy involves the following:

1. Fix two ranging rods vertically in the ground at points A and B 10m apart. Fix a level (point) on the ranging rod at point A by marking it or fixing a profile board at a definite distance above the ground, say 1 metre.
2. Fasten a string on the fixed level on the ranging Rod at A and hold the other end against the the one at B so that it is approximately horizontal.
3. Hook the line level to the string approximately midway between the two ends.
4. Adjust the end of the string against the rod at B until the spirit bubble is centred. Mark the point at which the string touches the ranging rod at B.
5. Keeping the line (string) in place, take the line level, and turn it round 180^{o} about a vertical axis and fix it on the line again. Follow step 4 above.
6. Check to see if the two marks (from step 4 and step 6 above) coincide. If the difference between the two marks is less than 10cm, take the point halfway between the two. If the difference is greater than 10cm, avoid using the line level.

FIGURE 9 - E1.3: CHECKING A LINE LEVEL FOR ACCURACY

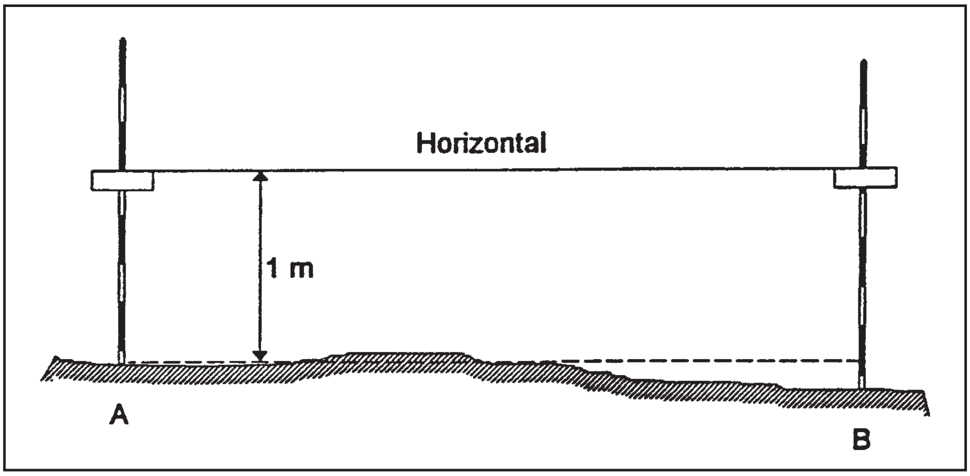


Transferring levels

The level at point A on the ground may be transfered to another B as follows:

1. Fix two ranging rods vertically in the ground at points A and B. Fix a level on the ranging rod at point A by marking it or fixing a profile board at a definite distance above the ground, say 1 metre above the ground.
2. Fasten a string on the fixed level on the ranging rod at A and adjust the end of the stretched string at rod B until a line level hooked to it has its bubble centred. The string is now horizontal and the point where it touches the rod at B is marked. This point is at the same level as the point on rod A (1m above ground).
3. Measure out 1 metre below the marked point on the ranging rod at B and mark this point too. This point will be at the same level as the ground level at point A. Note that if the ground level at B is higher than the ground level at A, the transferred level shall be below ground level. If the ground level at A is higher than at B, then the transferred level shall fall above ground level.

Figure 10 - E1.3: Transfering levels



Establishing new levels

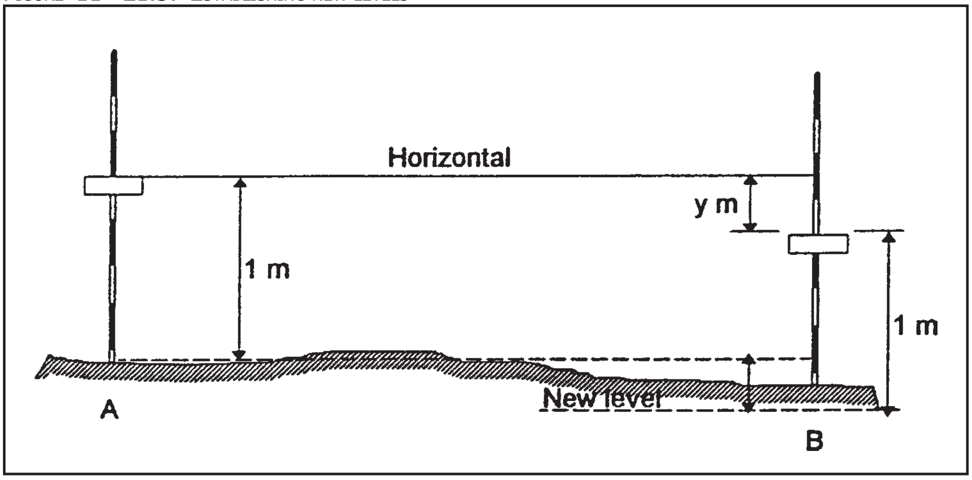
The following procedure involves setting out a defined level above or below another known level.

1. Fix two ranging rods vertically in the ground at points A and B. Fix a level on the ranging rod at point A by marking it or fixing a profile board at a definite distance above the ground, say 1 metre above the ground.
2. By using a string and line level, obtain and mark point at B at the same level as the mark on rod at A (1m above). The horizontal level is attained when the spirit bubble is centred.
3. If the new level required at B, say y metres **above** the ground level at point A, then **obtain** the difference (1 - y) metres. Measure out this difference (1 - y) metres **below** the marked point on the ranging rod at B. This point will be ym above the ground level at point A.

Note that if the difference becomes negative,
measure out above the marked point of the ranging rod at point B.

4. Similarly, if the new level required at B, say **y** metres **below** the ground level at point A, then, **add y** metres to 1 metre. Measure out this sum (1 + y) metres **below** the marked point on the ranging rod at B. This point will be **y** metres below the ground level at point A.

FIGURE 11 - E1.3: ESTABLISHING NEW LEVELS



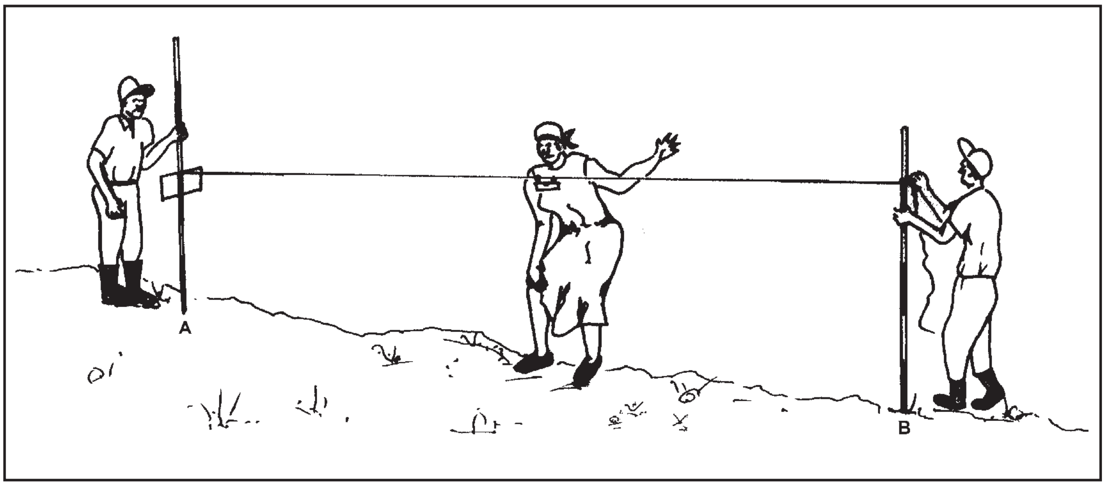
Finding the gradient of a slope

This procedure is useful when setting out vertical alignment. The procedure is outlined below:

1. Fix two ranging rods vertically in the ground at points A and B along the slope to be measured. Point A is higher than point B. The horizontal distance between the two rods should be 10 m.
2. Fix a level mark on both ranging rods by marking them or fixing profile boards at a definite distance above the ground, say 1 metre above the ground.
3. Using the methods described above, establish and mark the point on rod at B at the same horizontal level as the mark on rod at A.
4. The difference in height between this new point obtained in step 3 above and the original mark at 1 metre above the ground represents the difference in levels between points A and B. *(The same difference in height can be obtained by measuring the distance from the ground to the final position of the string on both rods and finding the difference between the two measurements.)*
5. The gradient is obtained by expressing the difference in height obtained in step 4 above over the horizontal distance between the 2 rods as a percentage.

Note: If the horizontal distance is 10 m, the difference in level from step 6 above is expressed in metres and multiplied by 10 to get the percentage gradient.

FIGURE 12 - E1.3: DETERMINING THE GRADIENT OF A SLOPE

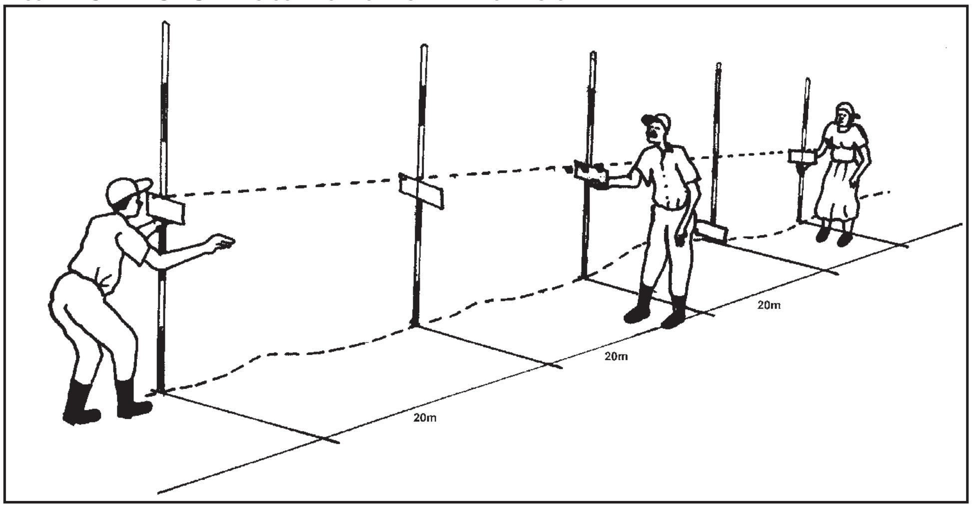


Setting out a uniform gradient on a slope

The procedure for setting out uniform gradients is outlined below:

1. Fix two ranging rods, each fitted with a profile board, at points 1 and 2, which mark the extremes of the gradient that needs to be set out. For sighting comfort, the distance between the two ranging rods should not be more than 120m apart.
2. Adjust the two profiles such that the tops are at a height of 1 metre above the required respective levels at each of the points 1 and 2.
3. Set out the straight line in between 1 and 2 using ranging rods spaced out at the required interval as described in the procedure earlier in this section.
4. Fit profile boards loosely on each of the intermediate ranging rods and lower the boards to the ground.
5. One worker sights through the profile boards at 1 and 2 from point 1 and directs a second worker to adjust the profile boards on the intermediate rods such that the top edges of all the profiles are flush with the sight line through profiles at 1 and 2.
6. The tops of all the profile boards are now at a uniform gradient. The desired levels of the uniform gradient shall all be 1 metre below the level of the tops of the profiles, which can be transfered with tape measures.

FIGURE 13 - E1.3: SETTING OUT A UNIFORM GRADIENT ON A SLOPE



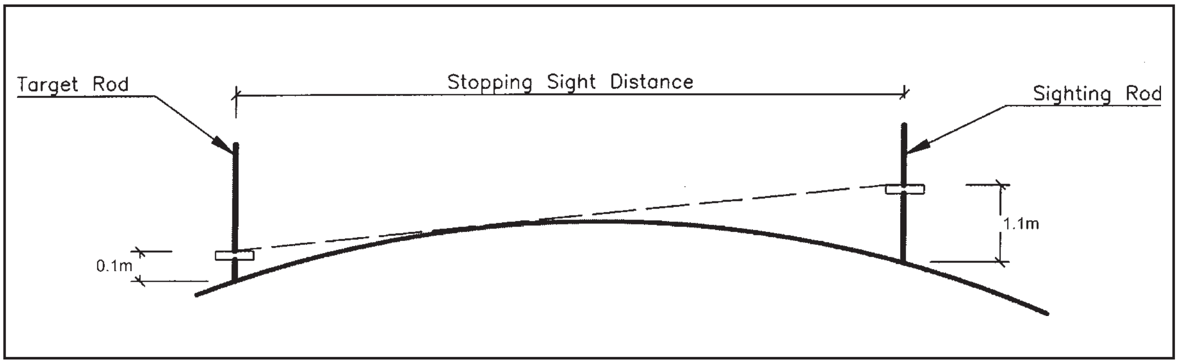
CHECKING SIGHT DISTANCES

Sight distance on crest curves

The procedure for checking the stopping sight distance for crest vertical curves is outlined below:

1. Fix a ranging rod (sighting rod) vertically with a profile board on the centerline on the approach to the crest. The profile board should be fixed with the top edge at 1.1 metre above the ground level.
2. Take a second ranging rod (target rod) with a profile board on the rod. The profile board should be fixed with the top edge at 0.1 metre above the ground level. Since the height of the board itself is 0.1 metre, it will literally rest on the ground.
3. A worker sights over the profile board on the sighting rod while another worker moves with the target rod away from the sighting rod along the road centerline, starting from the crest. The target rod is moved until the top edge of the profile can just be seen over the hill crest by the worker from the sighting rod.
4. The target rod is then fixed at this point and the horizontal distance between the two ranging rods measured. The distance thus measured is the sight distance. The sight distance must always be greater than or equal to the minimum stopping sight distance recommended by the design standards.

FIGURE 14 - E1.3: CHECKING SIGHT DISTANCES ON VERTICAL CURVES

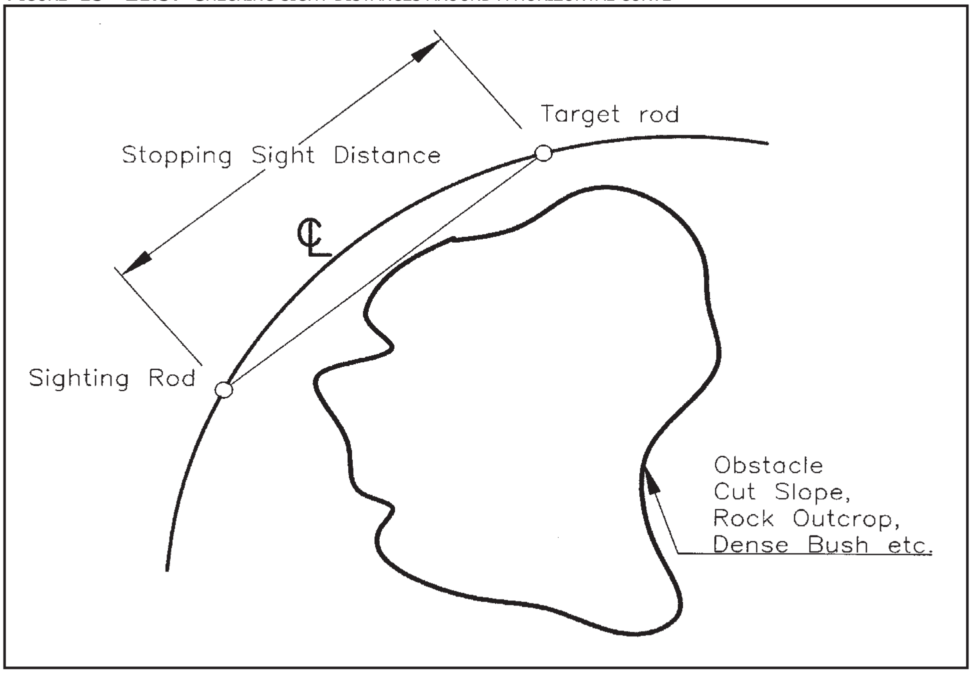


Sight distance around Circular horizontal curves

The procedure for checking sight distances around horizontal curves is outlined below:

1. Fix the sighting ranging rod on the road centre line in the curve **before** the point where the obstacle is closest to the centre line.
2. One worker moves along the centerline **after** the point where the obstacle is closest to the centre line away from the sighting rod.
3. The sight distance is found at the point where the target rod can just be seen past the target rod.

FIGURE 15 - E1.3: CHECKING SIGHT DISTANCES AROUND A HORIZONTAL CURVE



CHECKING THE RADIUS OF A CIRCULAR HORIZONTAL CURVE

When setting out horizontal alignment using existing alignment, it is necessary to check the radius of the curves to determine their conformity with the design standards to which the road is being improved.

The procedure for checking the radius of a curve is outlined below:

1. Establish three points A, B and C (**Figure 16-E1.3**) on the centre line of the road each point being 10m (measured along the centre line) away from the next. Note that if the centre line of the existing road is difficult to determine, the line of the side drain may be used as an approximation.
2. Stretch a string between points A and C and mark the midpoint of this line by measuring out with a tape.
3. Measure the distance from B to the midpoint of line AC in centimetres. This is the offset that we shall call X cm.

The offset X is related to the curve radius by the formula:

$$\boxed{R = \frac{5000}{X}}$$

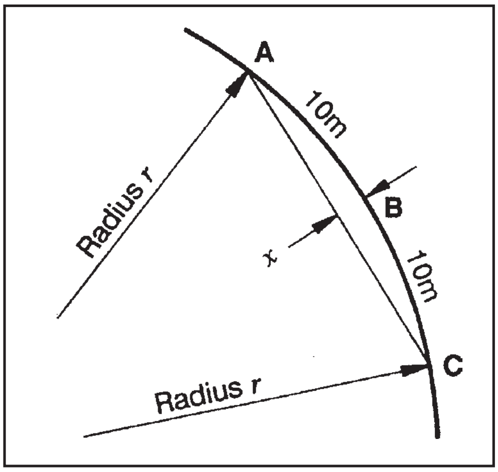
Where R = curve radius in metres

X = offset in cm

For the desirable minimum radius conditions:-

CURVE RADIUS (m)	OFFSET X (cm)
50 100	100 50

FIGURE 16 - E1.3: CHECKING RADIUS OF CURVE



If the centre line of the road is difficult to determine, use the line of the side ditch as an approximation.

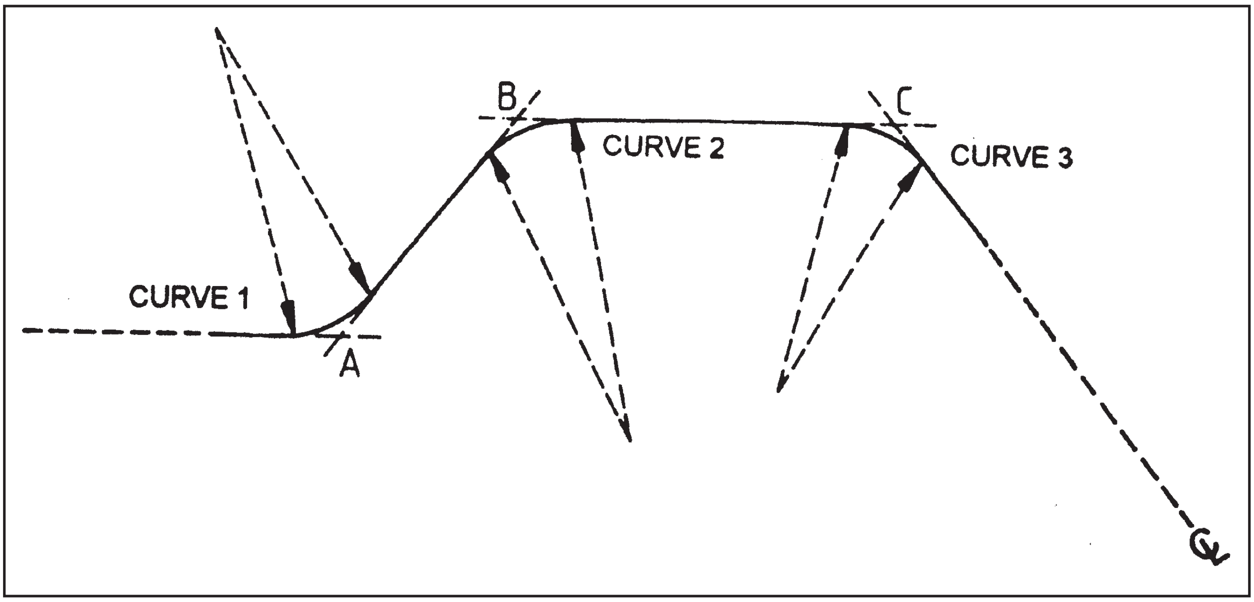
E1.4 SETTING OUT HORIZONTAL ALIGNMENT

Horizontal alignment standards and general road alignment considerations have already been described in **Sections B2** and **E1** respectively. This section is limited to the setting out of the horizontal alignment consisting a series of straight joined or punctuated by curves.

The overall process of setting out horizontal alignment therefore involves the following:

1. Setting out of straights (nearly along the proposed centre line) as described below.
2. Setting out curves using the appropriate methods and in accordance to the standards described in **Section B2**.
3. Placing or fixing centre line pegs at intervals of 10m or 20m in straight sections and 5m or 10m in curved sections and linking them as a continuation chainage pegs at the road side (at intervals of 20m).

FIGURE 1 - E1.4: EXAMPLE OF HORIZONTAL ALIGNMENT

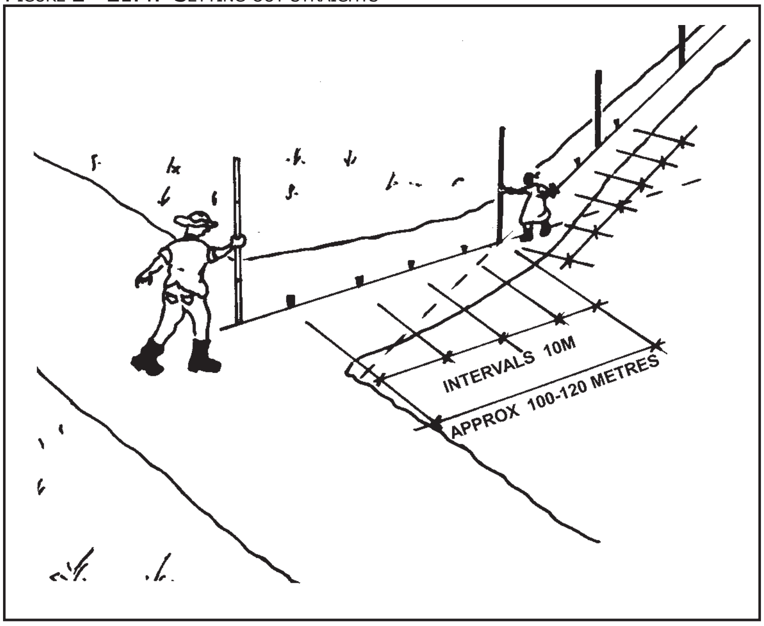


SETTING OUT STRAIGHTS

The overall procedure of setting out straights in the road alignment is simple and involves the following procedure:

1. The series of straight sections are set out using the methods described in **Section E1.3** of this manual. The intersection points (IPs) of consecutive straights can be established during this stage, (see **Figures 1** and **2** of **E1.4**).
2. Having set out the straights, centreline pegs at 10m intervals are fixed and the distances on pegs labelled in conformity with the road centreline chainage.

Figure 2 - E1.4: Setting out straights



SETTING OUT HORIZONTAL CURVES

There are a number of methods that are available for setting out horizontal curves depending on the prevailing conditions. The methods described in this manual and the situations under which they are used are summarised in **Table 1-E1.4**. Curves must be set according to the standards set in this manual in **Section B2** or as designed by the Engineer. Having get out curves, centreline pegs at intervals of 10m or 5m (for smoothness) can be fixed in conformity with the general road chainage.

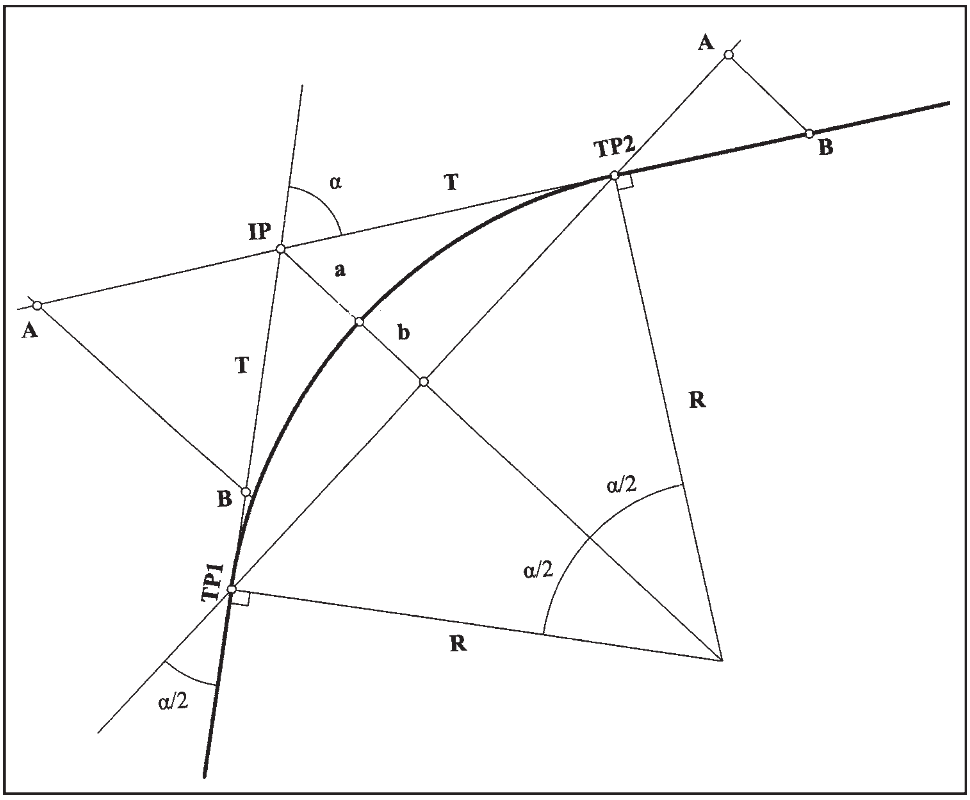
TABLE 1 - E1.4: METHODS FOR SETTING OUT HORIZONTAL CURVES

METHOD	APPLICATION
STRING METHOD	• Only suitable for small curve radii of less than 30 m • The area must be flat and free of obstructions • Most suitable for junction curves and hairpin curves
QUARTER METHOD	• Suitable for short curves • Where a string can be stretched unobstructed between the ends of the two straights.
TANGENT METHOD	• Suitable for any curve with deflection angle between 20° and 90° • The point of intersection of the two straights (PI) and the area between it and the road must be flat and free of obstructions.
OFFSET METHOD	• Suitable for any curve • Requires trial and error approach for the application to an existing alignment
DEFLECTION ANGLE	• Suitable for any curve. • Adequate on its own for shorter curves but requires use of quarter method for longer curves for additional points.
TANGENT OFFSET METHOD	• For curves with deflection angle of less than 20° • The point of intersection of the two straights (PI) and the area between it and the road must be flat and free of obstructions.

Properties of circular curves

The methods described in this section do not necessarily require knowledge of the properties of circular curves shown in **Figure 3-E1.4**.

FIGURE 3 - E1.4: PROPERTIES OF CIRCULAR CURVES



The basic formulae used to describe the circular curve are:

$$T = R \times \tan(\alpha / 2)$$

$$a = R \times [\{1 / (\cos(\alpha / 2))\} - 1]$$

$$b = R \times [1 - \cos(\alpha / 2)]$$

Where R = Curve radius

T = Tangent length = IP to TP_1 = IP to TP_2

IP = Intersection point of the 2 straights being connected by a circular curve

TP_1 = Beginning of circular curve

TP_2 = End of circular curve

MP = Midpoint of circular curve

C = Midpoint of chord joining the curve tangent points TP_1 and TP_2

α = Deflection angle
(i.e. the angle through which the curve turns from one straight to the next)

a = Offset from IP to midpoint (MP) of circular curve.

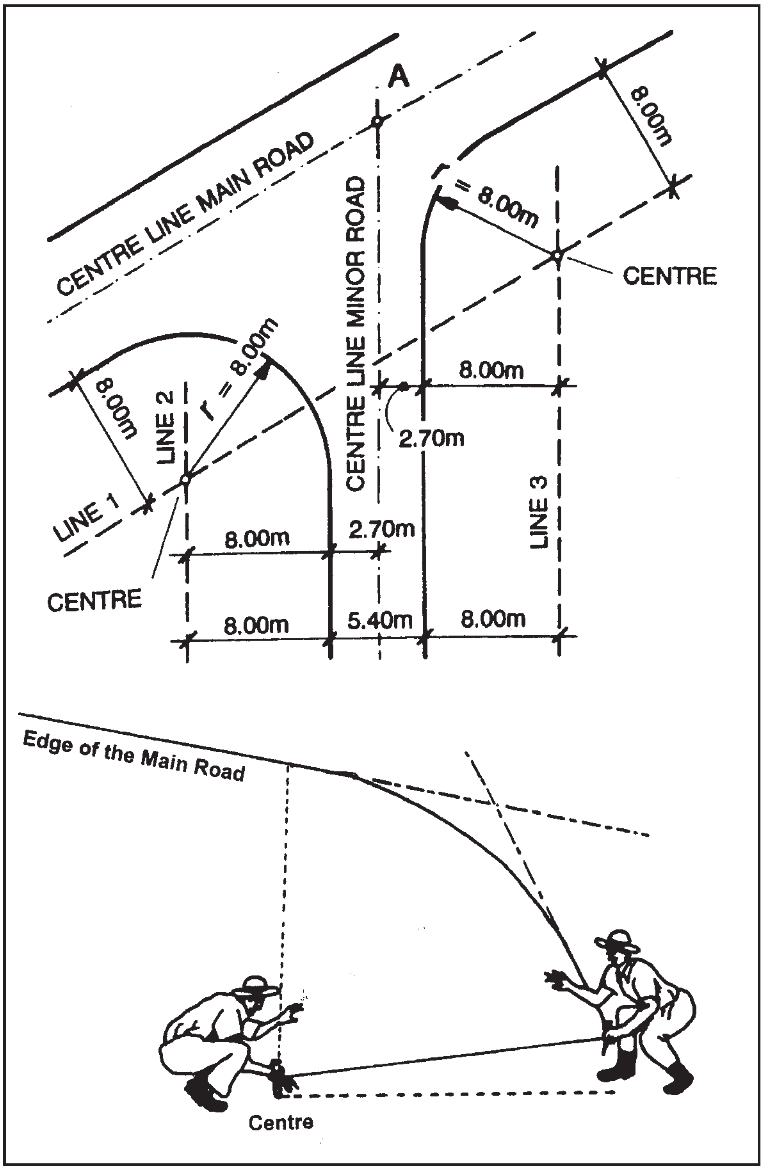
b = Offset from midpoint (MP) of circular curve to midpoint (C) of chord joining TP_1 to TP_2

String method

Steps to follow using string method:

1. Determine the carriageway edge of the existing main road. Mark it with a string.
2. Set out line 1, parallel to the edge of the main road and at the selected radius distance (e.g. 8m) from it. Mark line 1 with a string.
3. Set out the carriageway edges of the minor road. Mark them also with strings.
4. Set out line 2, parallel to the edge of the minor road and at the radius distance selected in step 2 from the left edge of the carriage-way. Set out line 3 on the other side of the road in a similar way.
5. The points of intersection between line 1 and 2 and between line 1 and 3 are the centres of the curves.
6. Use a string of radius length to draw the curves using the centres from step 5 and set out the curves.

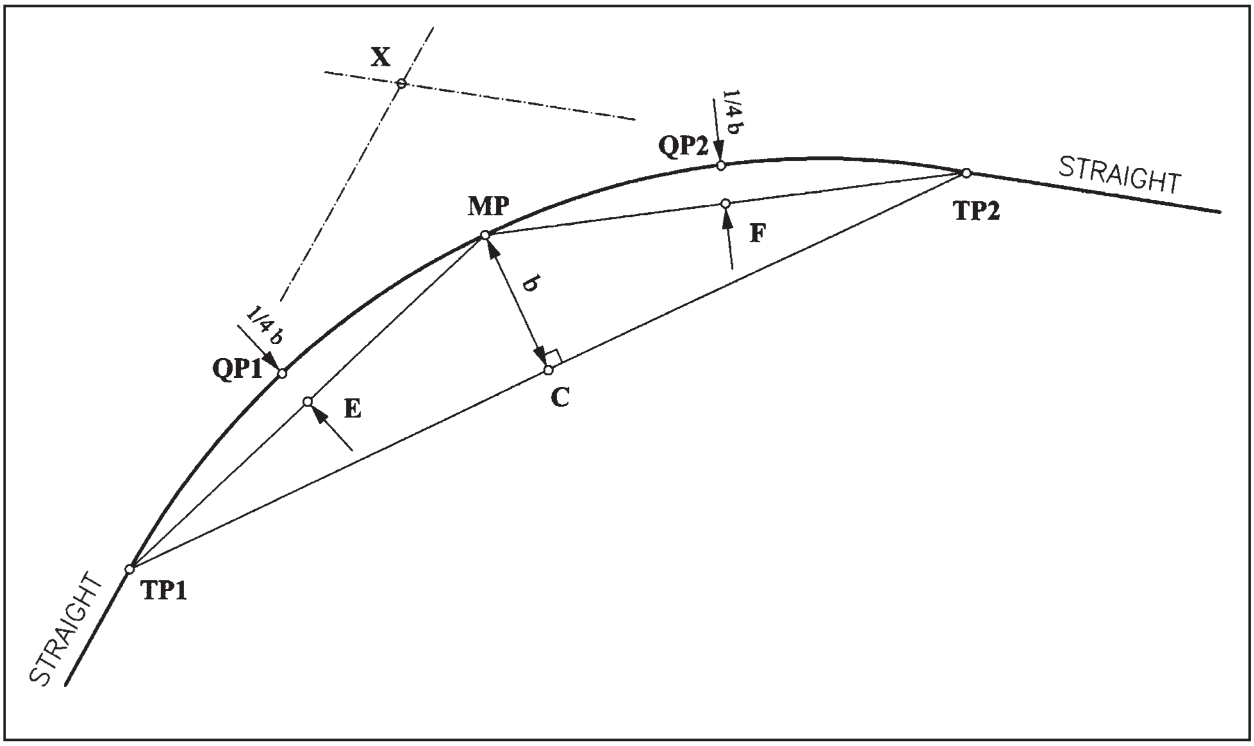
FIGURE 4 - E1.4: SETTING OUT JUNCTION CURVES USING STRING METHOD



Quarter method

The steps to follow are listed below:

FIGURE 5 - E1.4: SETTING OUT CURVES USING THE QUARTER METHOD

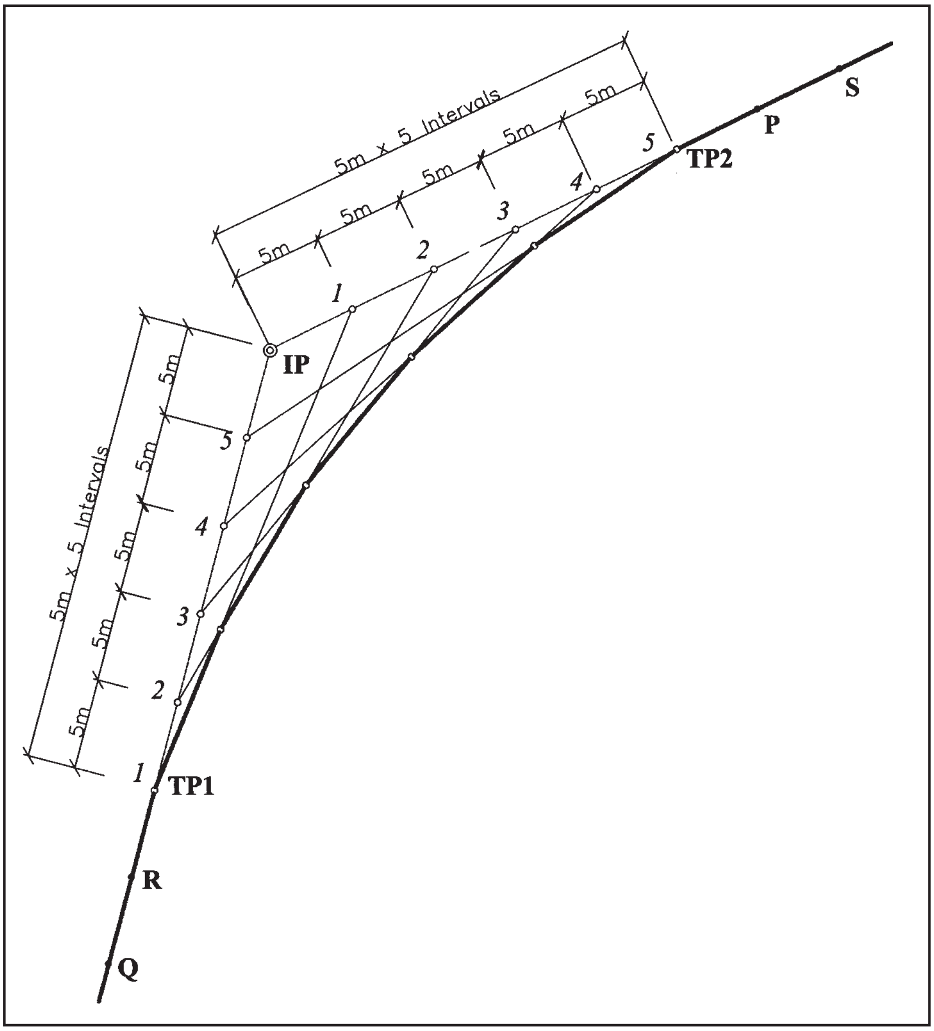


1. Establish the ends of the straights, TP_1 and TP_2. They should be approximately equal distances from the IP.
2. Establish point C exactly halfway between points TP_1 and TP_2.
3. Establish point MP opposite C on the desired centre line of the road such that the line C-MP is perpendicular to line TP_1- TP_2.
4. Establish points E and F exactly halfway between TP_1-MP and MP- TP_2 respectively.
5. Measure out the distance C-MP (**b**).
6. Set out points QP and QP at distances **¼b** from points E and F respectively. The line E-QP must be perpendicular to TP_1-MP and F-QP must be perpendicular to MP- TP_2.
7. Check radius of curve as described in **Section E1.3** of this manual. If the curve radius is insufficient, move points TP_1 and TP_2 apart and restart from step 1.
8. Place intermediate pegs if necessary to form smooth curve with string line.

Establish centre line pegs at 5m or 10m intervals and chainage reference pegs.

Tangent method

FIGURE 6 - E1.4: SETTING OUT CURVES USING TANGENT METHOD



1. Establish the intersection point IP. In the case of an existing curve, establish IP by extending lines QR and SP.
2. Choose the most suitable tangent length and establish points TP_1 and TP_2 with pegs.
3. Divide the tangent lengths IP- TP_1 and IP- TP_2 into an equal number of parts by fixing pegs and numbering them as shown in **Figure 6-E1.4**.

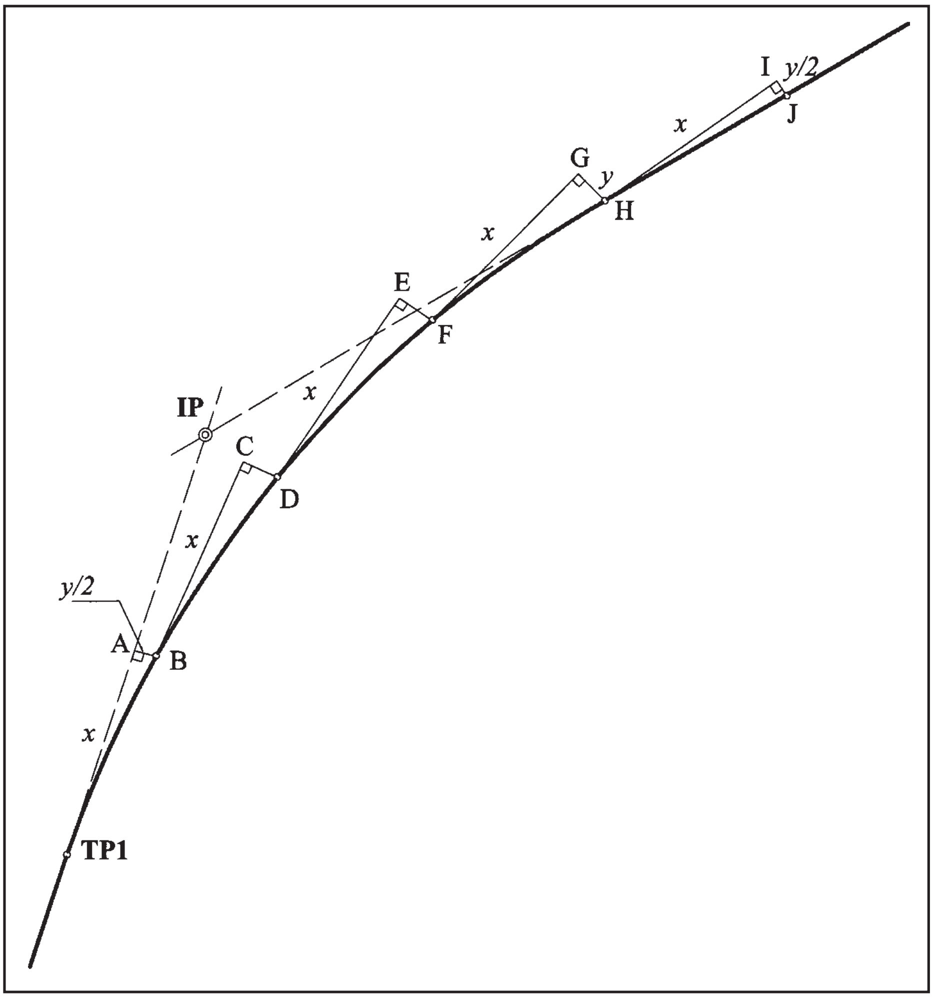
Note, the more curve points are required, the more the number of parts into which the tangent lengths must be divided.

---

4. Join point 1 on tangent IP- TP_1 to point 1 on tangent IP- TP_2 with a stretched string. Similarly, join all the pegs sharing the same number with a tightly stretched string. The points on the curve lie at the intersection of lines 1-1 with 2-2, 2-2 with 3-3, etc.
5. Check radius of curve as described in **Section E1.3** of this manual. If the curve radius is insufficient, move points TP_1 and TP_2 apart and restart from step 1.
6. Place intermediate pegs if necessary to form a smooth curve with a string line.
7. Establish centre line pegs at 10m intervals and chainage reference pegs.

Offset method

FIGURE 7 - E1.4: SETTING OUT CURVES USING THE OFFSET METHOD



This method is a trial and error approach for existing alignments where the intersection point cannot be established by virtue of its physical location e.g. if it falls in a valley.

The steps to follow:

1. Choose the beginning of the curve (TP_1) as a trial by looking at the existing alignment and estimating the original beginning of curve.

2. Assume a distance x which is normally 10m but can be any suitable figure depending on the curve radius. **Table 2-E1.4** can be used as a guide to choose x.

   For any given radius R and assumed distance x, the offset y can be calculated from the formula:

$$Y = \frac{X^2}{R}$$

From the formula, the value of y is usually rounded off to the nearest 5cm. **Table 2-E1** gives x and y values for common curve radii used in horizontal alignment.

3. Set out point A on the tangent at distance x from TP1 in the direction of the IP. This is done by extending the straight before point TP_1.

4. Set out an offset perpendicular to the tangent at point A and at a distance of ½y from A to get point B on the curve.

TABLE 2 - E1.4: VALUES OF X AND Y DEPENDING ON THE RADIUS

Radius (m)	Distance x (m)	Offset y (m)	Distance x (m)	Offset y (m)
500	10	0.20	20	0.80
450	10	0.22	20	0.89
400	10	0.25	20	1.00
350	10	0.29	20	1.14
300	10	0.33	20	1.33
250	10	0.40	20	1.60
200	10	0.50	20	2.00
150	10	0.67	20	2.67
100	10	1.00	20	4.00
50	5	0.5	10	2.00
40	5	0.63	10	2.50
30	5	0.83	10	3.33
15	5	1.67	10	6.67

5. Set out point C with a distance x from B on the extension of line TP_1-B.
6. Set out an offset perpendicular to the line BC at point C and at a distance of y from Y to get point D on the curve.
7. Set out point E with a distance x on the extension of line DE.
8. Set out an offset y (from E) to get point F on the curve.
9. Repeat steps 7 and 8 to set out point TP_2 (the end of the curve).
10. Set out an offset ½ y from I to get to point J. Point J should fall on the second straight.

    If it is not possible to reach the end of the curve (TP_2) satisfactorily, the entire procedure has to be repeated by selecting another point for the beginning of curve (TP_1) or adjusting y until L falls on the second straight.
11. Establish centre line pegs at 10m intervals and chainage reference pegs.

Deflection angle method

FIGURE 8 - E1.4: PROPERTIES OF CIRCULAR CURVES

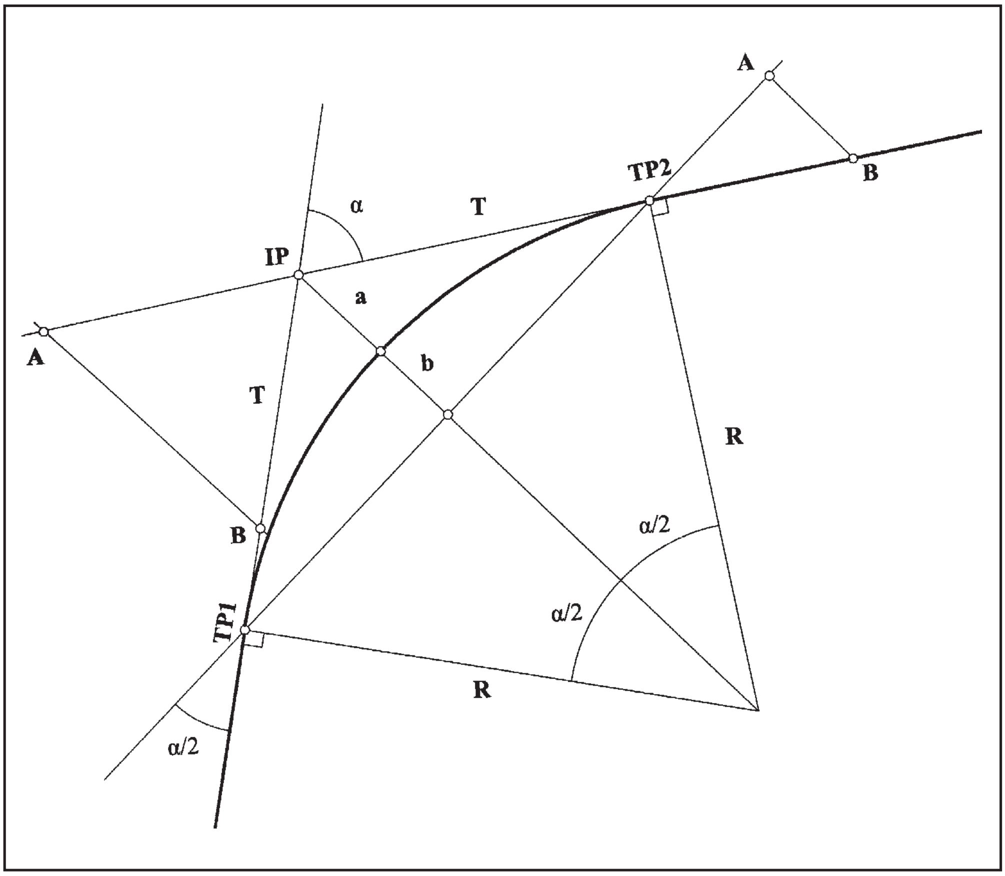
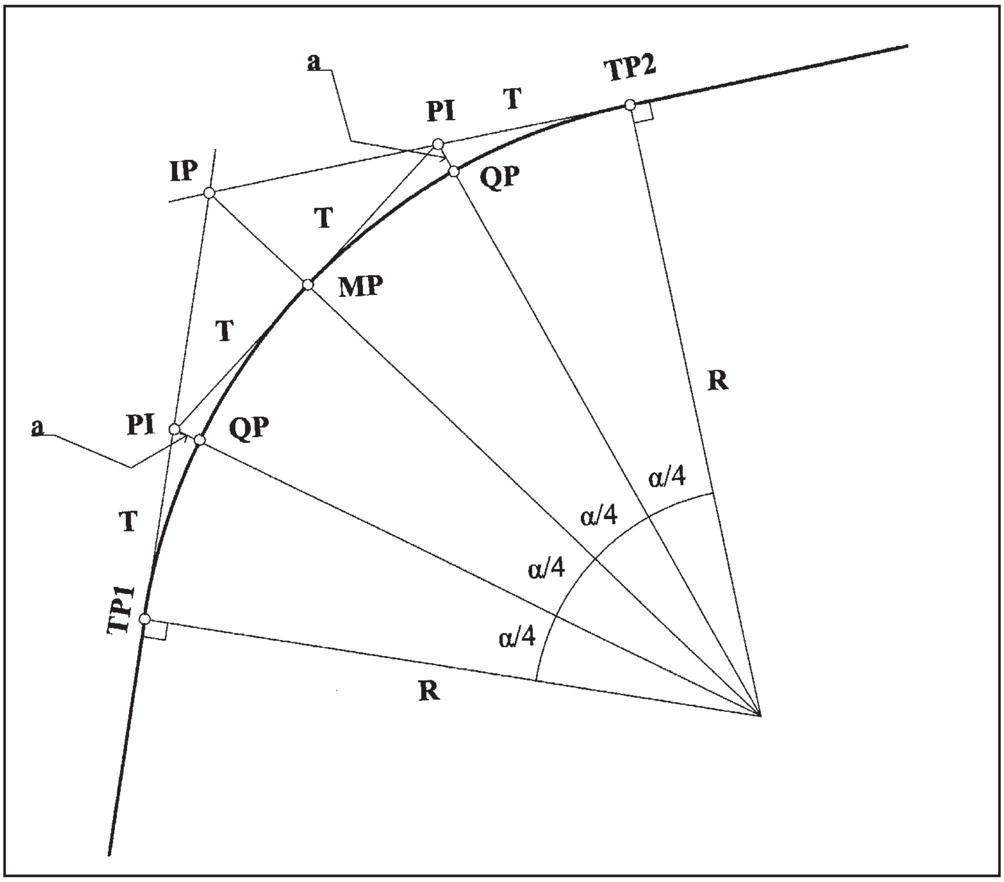


FIGURE 9 - E1.4: SETTING OUT CURVE USING THE DEFLECTION ANGLE METHOD



The steps to follow are listed below:

1. Referring to **Figure 8-E1.4** (the one showing the curve properties), set out A and B 10m or 20m from IP and measure out the distance A-B. Read off the deflection angle α from the graph in **Figure 10-E1.4.**

   [Alternatively, choose T (the tangent length), preferably as a multiple of 10m, and set out TP_1 and TP_2. Then set out A and B at 10m or 20m from either TP_1 (beginning of curve) or TP_2 (end of curve). Measure A-B and read off the angle from **Figure 10-E1.4**. This angle will be half the deflection angle therefore, multiply it by 2 to get the deflection angle α.]

2. Choose tangent length T and check the curve radius R.

   a) Once you have found angle α and chosen T, the curve radius R and all other perameters of the curve are determined from the curve formulae. The relationship between α, T and R is shown in **Figure 11-E1.4**. Use the diagram or calculate the deflection angle using the curve formulae.

   b) In situations where a particular curve radius is required, it might be better to start with the radius and read off T from the diagram in **Figure 11-E1.4**.

   c) Fix pegs at TP_1 and TP_2. (TP_1 and TP_2 are a distance T away from the PI along the two straights).

3. Find T^1 and set out IP^1 and MP (curve midpoint) as shown in **Figure 9-E1.4**.

   a) The relationship between angle α, T and T^1 is shown in **Figure 12-E1.4** as given by the formula:

$$T^1 = T \times [\{\tan (a / 4)\} / \{\tan (a / 2)\}]$$

   Read off T’ from the diagram in **Figure 12-E1.4** and set out the two IP^1s at distance T^1 from TP_1 and TP_2 respectively.

   b) Sight in and place a peg at MP as the midpoint between the two IP^1s.

4. Find offset a and set out QP (quarter points)

   a) The relationship between angle α, T^1 and offset (a) is shown in **Figure 13-E1.4**. Read off angle α from the diagram and set out the two QPs at distance (a) from IP^1 the line bisecting the angle TP_1- IP^1-MP.

5. Fix pegs at the two QPs and inspect the curve by pulling a string line through the curve points TP_1, QP, MP, QP and TP_2.

   With shorter curves, these points are sufficient to set out the curve. However, with longer curves, it may be necessary to obtain more points using the quarter method described in this **Section E1.4**.

6. Establish centre line pegs at 10m intervals and chainage reference pegs.

FIGURE 10 - E1.4: DEFLECTION ANGLE AS A FUNCTION OF DISTANCE A - B

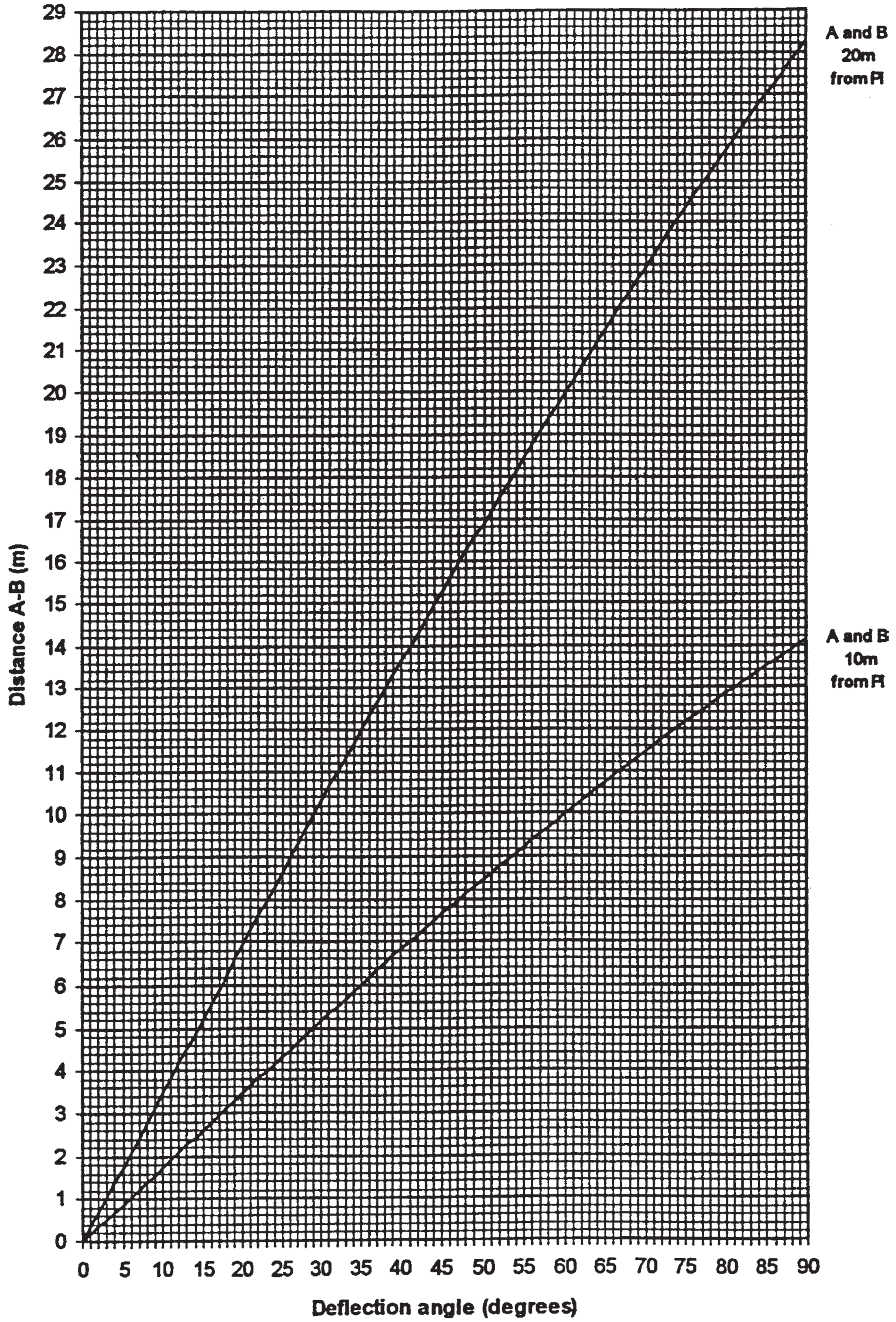


FIGURE 11 - E1.4: TANGENT T AS A FUNCTION OF DEFLECTION ANGLE AND CURVE RADIUS

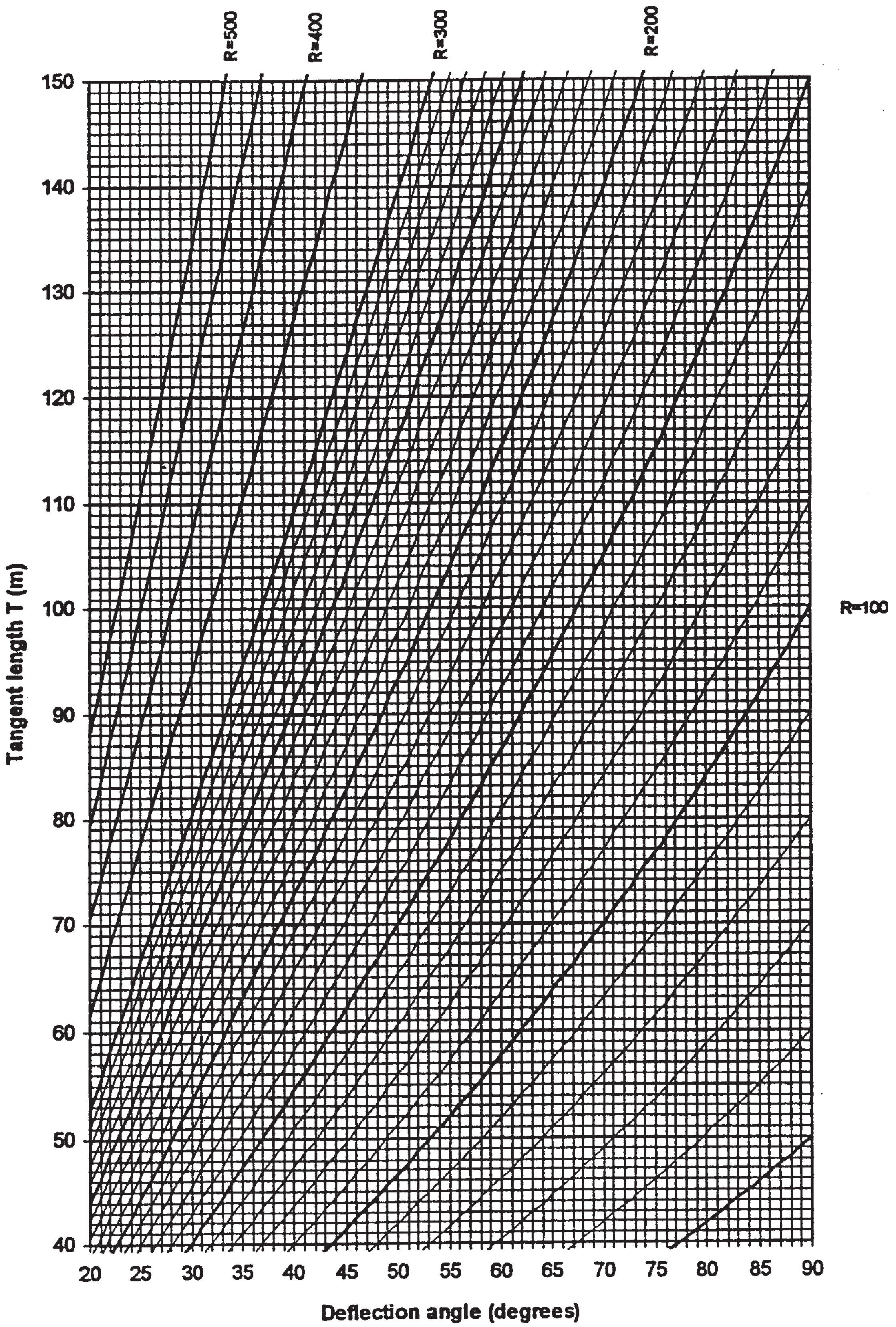


FIGURE 12 - E1.4: TANGENT T AS A FUNCTION OF DEFLECTION ANGLE AND CURVE RADIUS

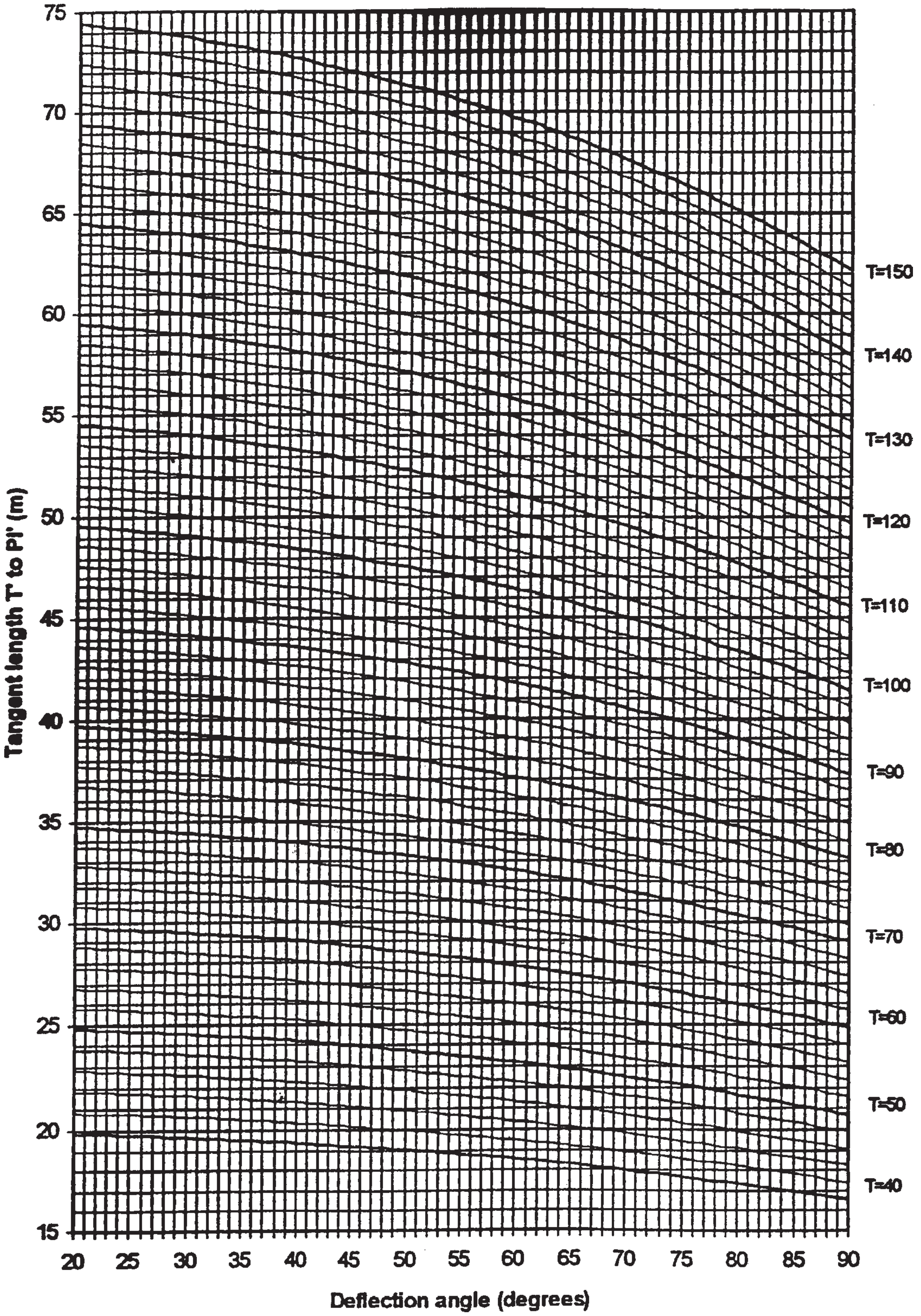
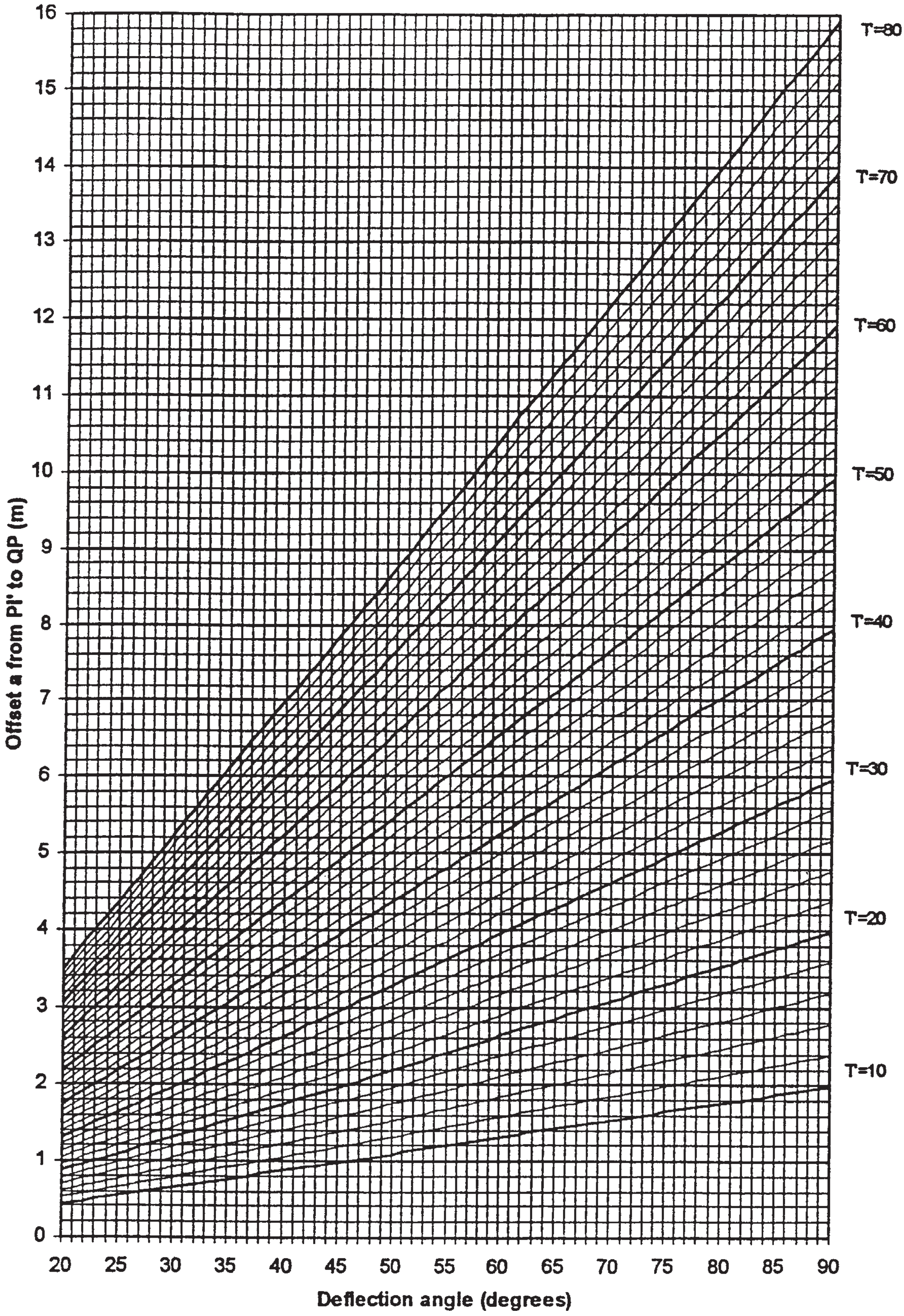
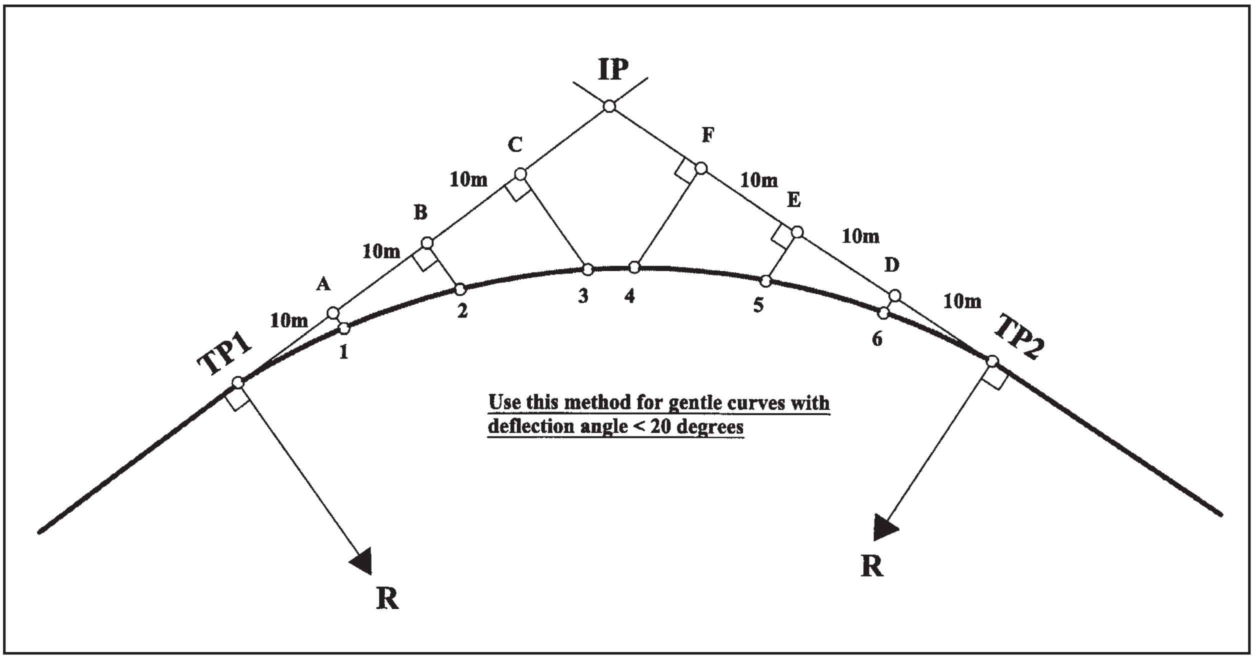


FIGURE 13 - E1.4: OFFSET (A) AS A FUNCTION OF DEFLECTION ANGLE AND T[1]



Tangent offset method

FIGURE 14 - E1.4: SETTING OUT CURVES USING TANGENT OFFSET METHOD



The steps to follow are listed below:

1. Determine the IP and find the deflection angle α as described in '**Deflection Angle Method**'. If the deflection angle is less than 20°, proceed to step 2. Otherwise, use another method.
2. Set out points TP_1 and TP_2 at equal distances from IP.
3. Set out temporary pegs along the tangents IP- TP_1 and IP- TP_2 at 10 m intervals.
4. From **Table 3-E1.4**, select the largest radius with as many offset points as the number of pegs you managed to fit along each tangent. (For **Figure 14-E1.4**, the largest radius will be 220m since there are only 3 pegs on each tangent, i.e. 220m is the largest radius that has exactly 3 offset points).
5. From the pegs on each tangent, set out right angles towards the desired curve, and measure out along each perpendicular the corresponding offset as read off the **Table 3-E1.4**. Fix pegs on the resultant points (1, 2, 3…..), which mark points on the curve.
6. Join the pegs (1, 2, 3….) with string line to form a smooth curve.
7. Establish centre line pegs at 10m intervals and chainage reference pegs.

TABLE 3 - E1.4: PERPENDICULAR OFFSETS FROM TANGENT (IN METRES)

Perpendicular offsets from tangent (m) for deflection angles <20⁰										
Curve Radius	Offset points from beginning and end of curve (m)									
	10	20	30	40	50	60	70	80	90	100
150	0.33	1.34								
160	0.31	1.25								
170	0.29	1.18								
180	0.28	1.11	2.52							
190	0.26	1.06	2.38							
200	0.25	1.00	2.26							
210	0.24	0.95	2.15							
220	0.23	0.91	2.06							
230	0.22	0.87	1.96	3.50						
240	0.21	0.83	1.88	3.36						
250	0.20	0.80	1.81	3.22						
260	0.19	0.77	1.74	3.10						
270	0.19	0.74	1.67	2.98						
280	0.18	0.72	1.61	2.87						
290	0.17	0.69	1.56	2.77	4.34					
300	0.17	0.67	1.50	2.68	4.20					
350	0.14	0.57	1.29	2.29	3.59	5.18				
400	0.13	0.50	1.13	2.01	3.14	4.53	6.17			
450	0.11	0.44	1.00	1.78	2.79	4.02	5.48			
500	0.10	0.40	0.9	1.60	2.51	3.61	4.92	6.44		
600	0.08	0.33	0.75	1.33	2.09	3.01	4.10	5.36	6.79	8.39
700	0.07	0.29	0.64	1.14	1.79	2.58	3.51	4.59	5.81	7.18
800	0.06	0.25	0.56	1.00	1.56	2.25	3.07	4.01	5.08	6.27
900	0.06	0.22	0.50	0.89	1.39	2.00	2.73	3.56	4.51	5.57
1000	0.05	0.20	0.45	0.80	1.25	1.80	2.45	3.21	4.06	5.01

Deflection Angle >20⁰
for tangents longer than
tabulated,
use another method

E1.5 SETTING OUT VERTICAL ALIGNMENT

The vertical alignment of the road which is set out after the horizontal alignment has been completed, has direct bearing on the construction cost, operating cost of vehicles and number of accidents.

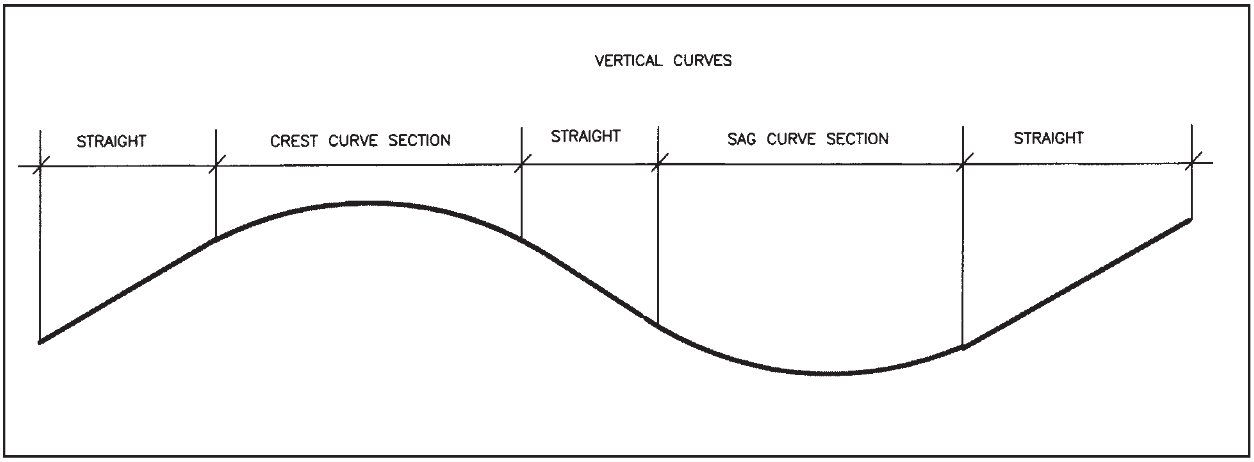
When setting out the vertical curves, the following points must be carefullyconsidered:

- Good correllation 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:

- Set out straight grades as described in **Section E1.3** of this manual.
- Set out gentle vertical curves (for minor up and down of the alignment)
- Set out the sag and crest vertical curves to join the straight grades.(for larger vertical curves)

FIGURE 1 – E1.5: CREST AND SAG CURVES



SETTING OUT STRAIGHT GRADES

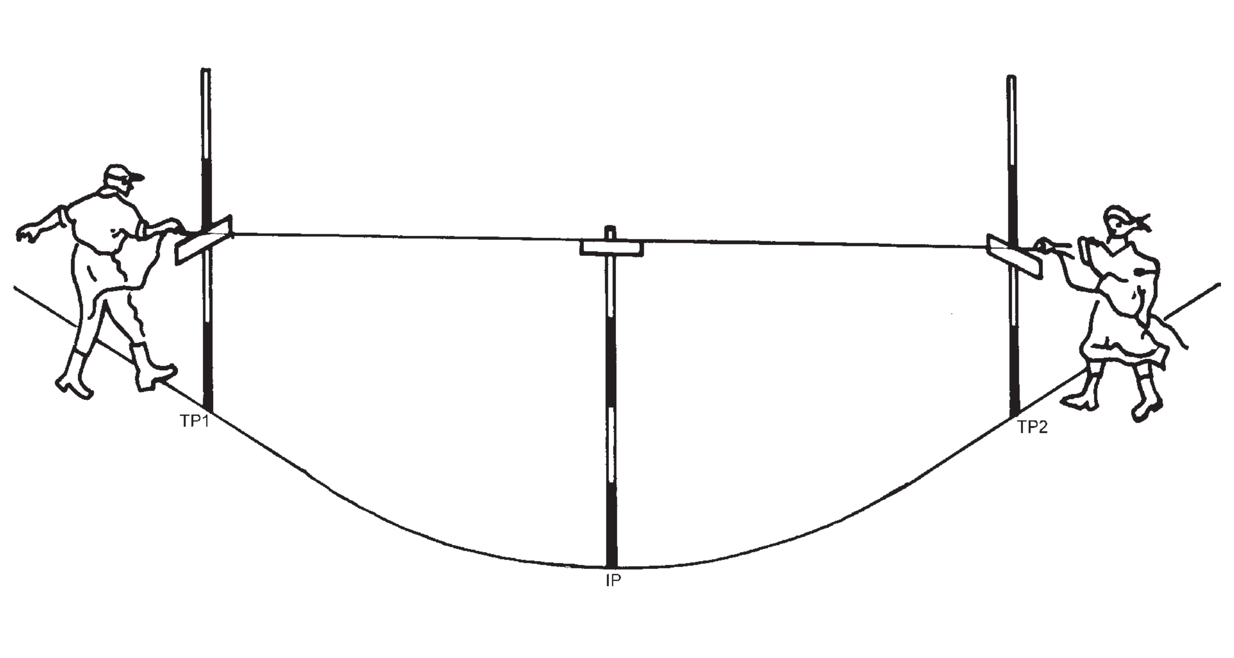
The setting out of straight grades is described fully in **Section E1.3** of this manual. The grades are expressed as percentages and can either be positive or negative.

The sign convention used in expressing straight grades in roadworks assumes that one is always moving in a direction from the beginning of the road (chainage 0+000) towards the end of the road (last chainage). Following this direction, upward sloping grades are positive (**+**) and downwards sloping grades are negative (**-**).

PROPERTIES OF VERTICAL CURVES

When two meeting gradients form a hill, the curve is called a **crest curve** and when the gradients form a valley, a **sag curve** is produced.

FIGURE 2 – E1.5: PROPERTIES OF VERTICAL CURVES



Where	TP_1	=	beginning of vertical curve (first tangent point)
	TP_2	=	end of vertical curve (final tangent point)
	L	=	length of vertical curve
	IP	=	intersection point of the two straight grades to be joined. It is midway between TP_1 and TP_2.
	MP	=	midpoint of vertical curve. This point bisects the line C-IP
	C	=	midpoint of straight line (chord) joining TP_1 and TP_2.
	p	=	gradient (%) of initial straight grade
	q	=	gradient (%) of final straight grade
	y	=	height of the curve above or below the first tangent point TP_1 at a horizontal distance x from TP_1
	x	=	horizontal distance from TP_1

The form of the curve is

$$y = ax^2 + b$$

Where

$$a = \frac{q - p}{200L}$$

$$b = p\ \%$$

The levels of IP and TP_2 above the first tangent point T are calculated by the formulae:

$$\text{Level of IP} = \frac{PL}{200}$$

And

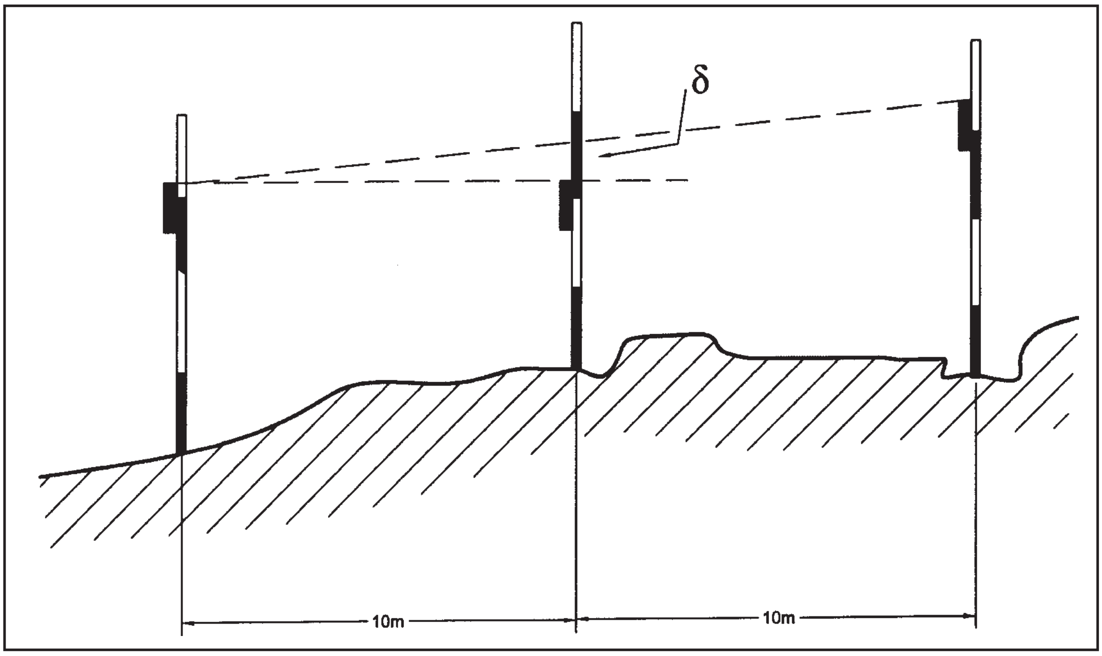
$$\text{Level of } TP_2 \ \frac{(q+p)}{200} \times L$$

SETTING OUT VERTICAL PROFILES

For gentle vertical movements of the road alignment, the road profile can be set out by eye using the profiles. The following steps can be followed:

1. Fix profile boards on the ranging rods along the centreline at a fixed level, say 1m above the ground level. (see **Figure 3-E1.5**)
2. Adjust the intermediate profiles through the curve until the difference in alignment δ between any three consecutive profiles is constant. A smooth vertical curve will then be established. (see **Figure 4-E1.5**)

FIGURE 3 – E1.5: MEASURE AND VALUE



3. Check with a tape measure. Normally, it should not exceed 10cm, but exceptions can be made in difficult terrain where it is obvious to drivers that they should slow down.
4. Check for balance of cut and fill and repeat with new starting points if necessary.
5. When the curve is acceptable, place new centreline pegs at each ranging rod with tops at 1m below the profile boards. This is the finished centreline. (see **Figure 5-E1.5**)

FIGURE 4 – E1.5: SETTING OUT VERTICAL PROFILES

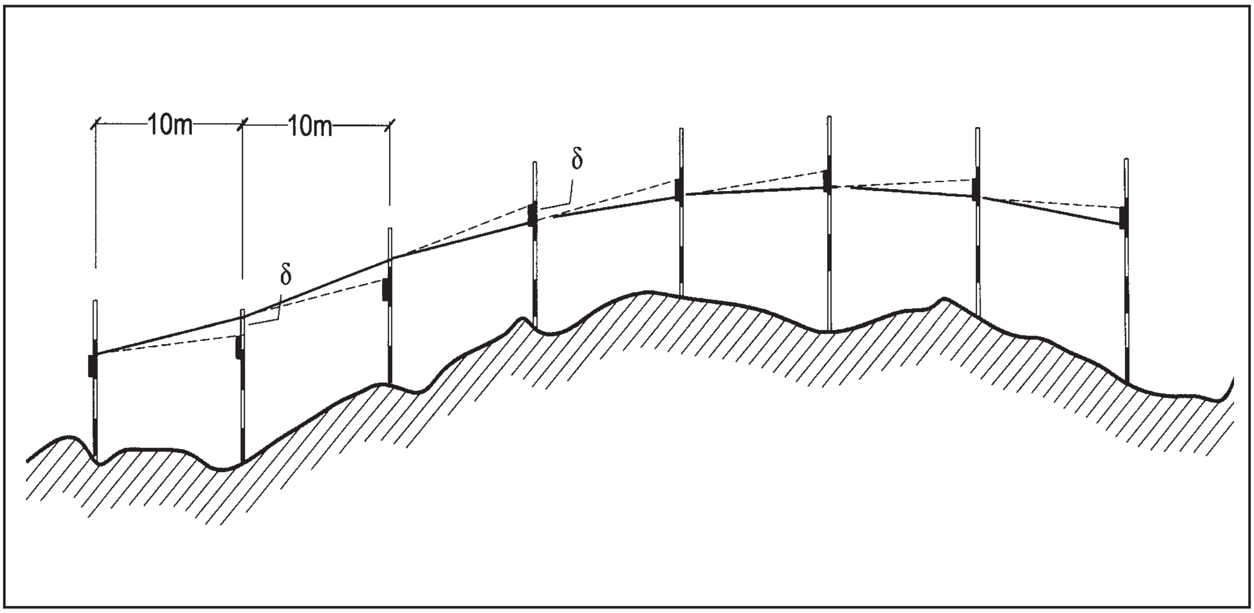
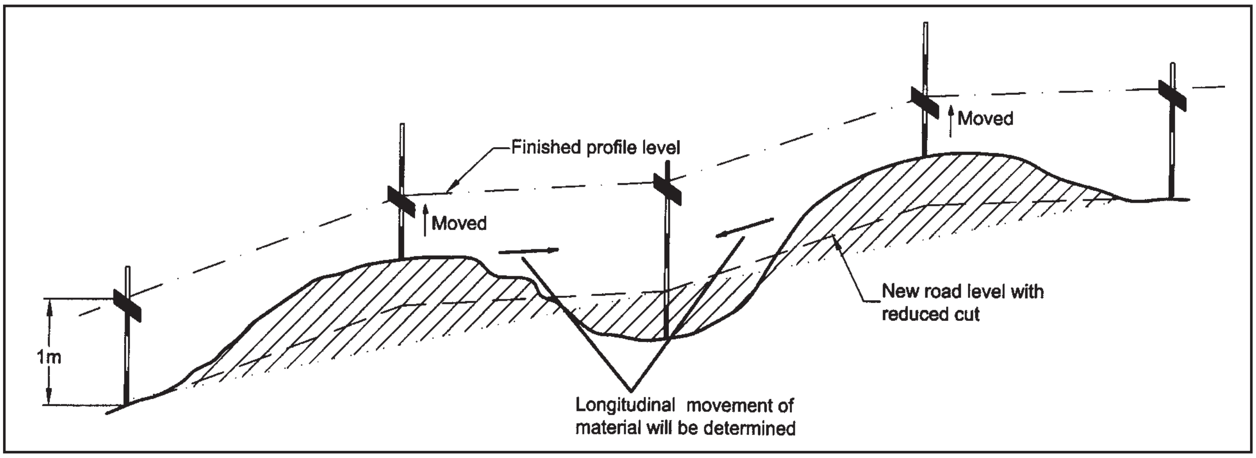


FIGURE 5 – E1.5: FINISHED PROFILE

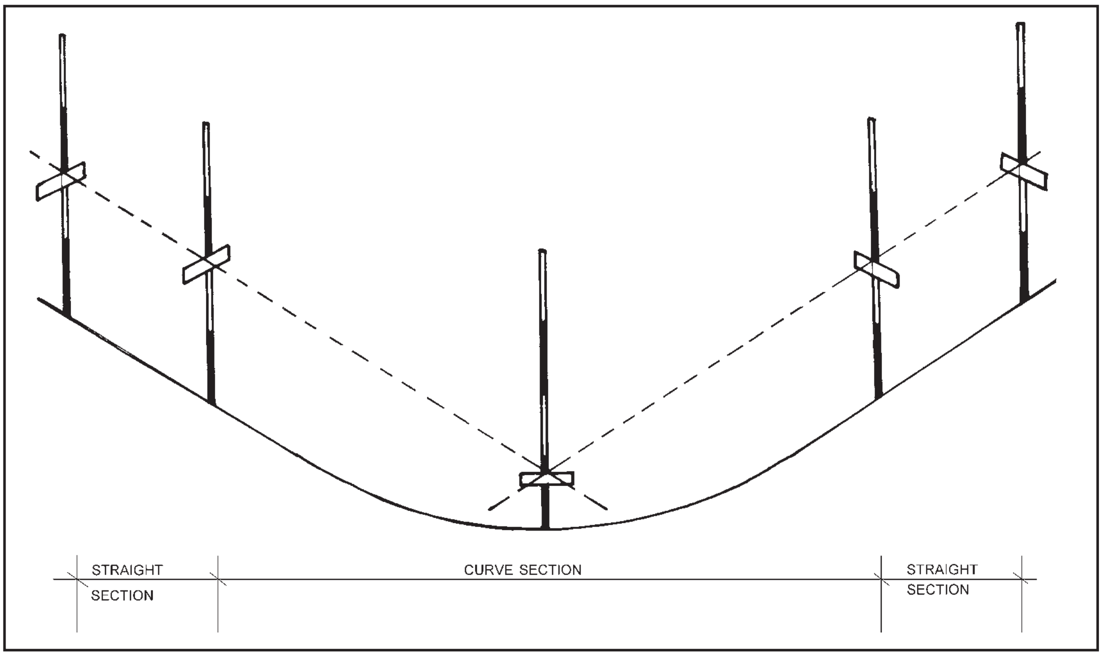


SETTING OUT A SAG CURVE USING THE PROFILE METHOD

A sag vertical curve can be set out quite easily using profile boards and string. The steps to follow are shown below.

1. Measure the gradients (**p** and **q**) of the two straight grades to be joined by following the procedure described in **Section E1.3** of this manual. (see **Figure 6-E1.5**)

FIGURE 6 – E1.5: LOCATING THE INTERSECTION POINT



2. Locate the intersection point (**IP**) of the 2 straight grades. In case the **IP** is under the ground level, increase the height of the profile board level in step 1 by equal distance so that the intersection point is above the ground level.
3. Choose the appropriate **K value** from the table below and multiply it by the algebraic difference between the two gradients (**p** and **q**) of the two straight grades to get the minimum length of the vertical curve. Then choose L (length of vertical curve) to be a multiple of 20, if possible, for ease of setting out.

TABLE 1 – E1.5: K VALUES FOR SAG CURVES

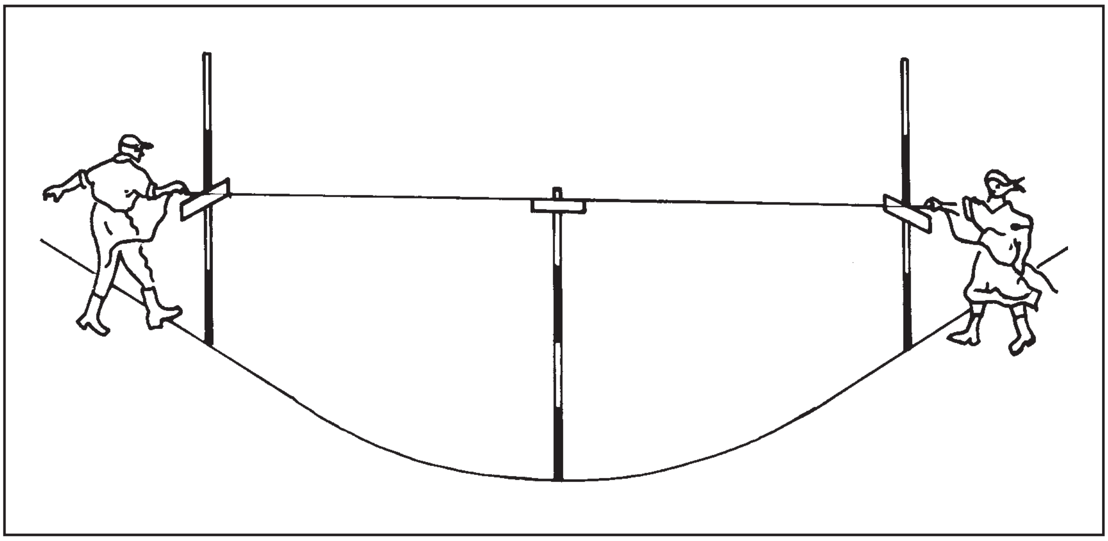
	Flat Terrain			Rolling Terrain			Hilly Terrain		
	Design speed			Design speed			Design speed		
	50	60	70	40	50	60	30	40	50
Sag K value (for safe stopping sight distance)	12	18	25	8	12	18	5	8	12
Sag K value (for comfort)	2.5	4	5	1.5	2.5	4	1	1.5	2.5

4. Measure both ways from the point **IP** a horizontal distance equal to half of the curve length (L) and fix ranging rods at both the beginning and end points of the vertical curve on the centerline (i.e. fix points TP_1 and TP_2).

5. Place profile boards on the two ranging rods at the beginning and end of the curve (i.e. points TP_1 and TP_2). Set the profile boards at each point to 1m above the desired road level.
6. Take a line of sight of string line over the top of the profiles at the two tangent points, and adjust the profile board at **IP** such that its top is in this line of sight (see **Figure 7** and **Figure 8** of **Section E1.5**). Put a chalk mark or a second profile board on the ranging rod at IP to mark the point at which the line of sight from TP_1 to TP_2 crosses this rod (at **IP**).

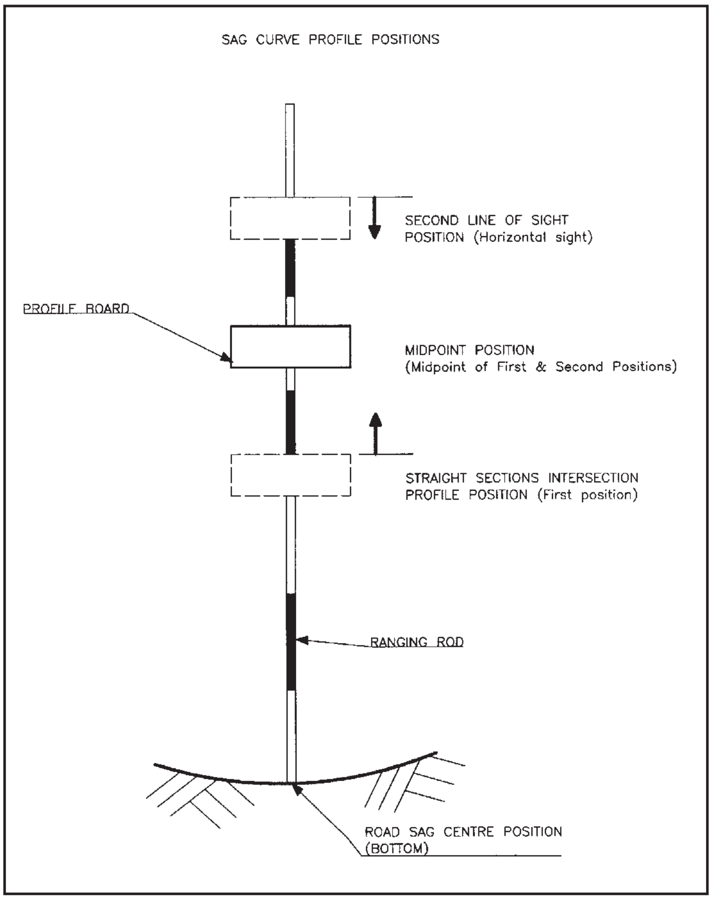
Note: The original level of the profile at IP must also be marked before moving the profile board up.

FIGURE 7 – E1.5:



7. 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. (See **Figure 8-E1.5**)

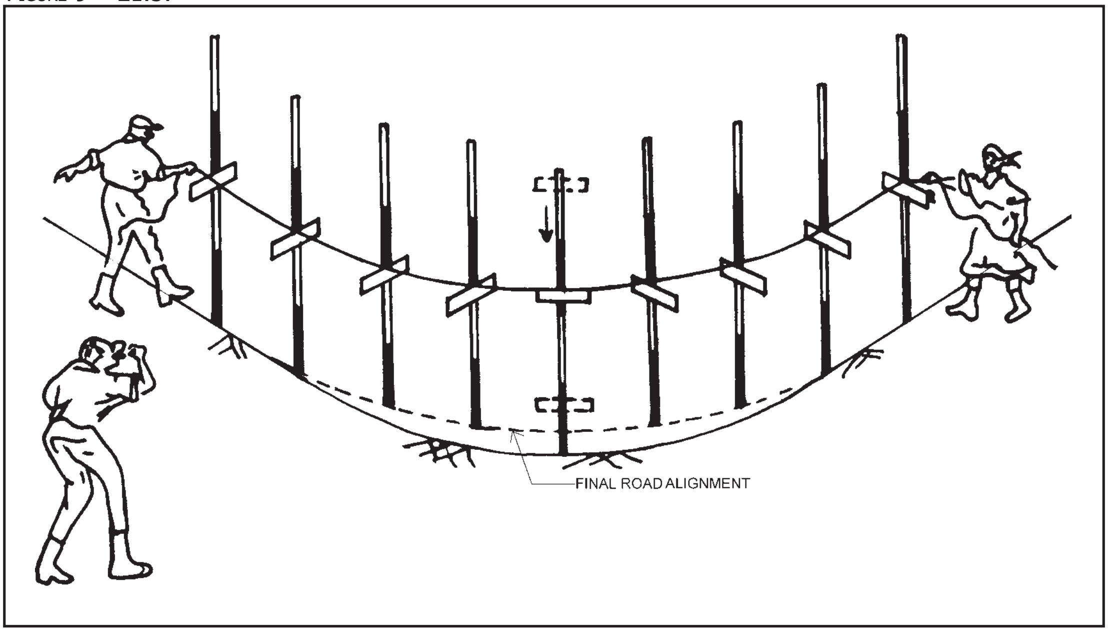
FIGURE 8 – E1.5:



8. Get a piece of string about twice the length of the sag curve. Tie one end at the top of the profile board at TP_1.

9. Walk towards TP_2 draping the string over the profile boards on the intermediate ranging rods and definitely over the profile board on the sag bottom 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 TP_1, the other end on top of the profile at TP_2 and the bottom of the sag on top of the profile at **IP**.

Figure 9 – E1.5:



10. Tie off the string at TP_2 and stand back to check that the sag curve formed by the string looks smooth with no sudden changes in grade. Having ensured this, adjust all the profile boards between TP_1 and TP_2 upwards towards the string so that they just touch the string. (see **Figure 9-E1.5**)

11. Remove the string and, once again, check that the adjusted profiles form a smooth a curve. If not, make slight adjustment as appropriate.

SETTING OUT CREST CURVES USING PROFILE METHODS

A crest curve may be set out using the profile in the same way as described for sag curves before. (see **Figures 10** to **14** of **Section E1.5**). The steps to follow are shown in the list below.

1. Measure the gradients (**p** and **q**) of the two straight grades to be joined by following the procedure described in **Section E1.3** of this manual. (see **Figure 6-E1.5**)

2. Locate the intersection point (**IP**) of the two straight grades. In case the **IP** is too high above the ground level and beyond the reach of the worker, decrease the height of the profile board level in step 1 by equal distance so that the intersection point can be reached.

FIGURE 10 – E1.5: SETTING OUT GRADES AND DETERMINING IP

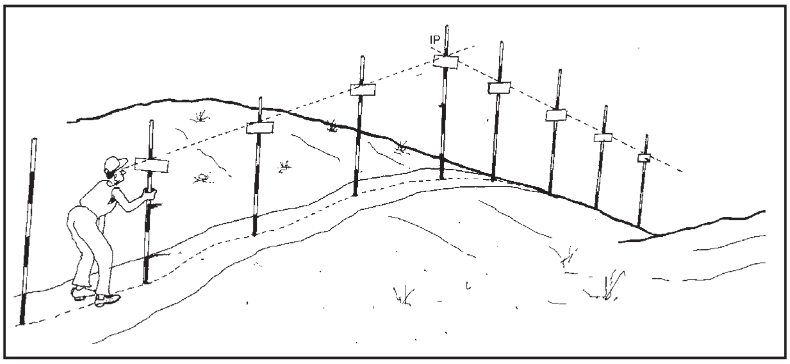
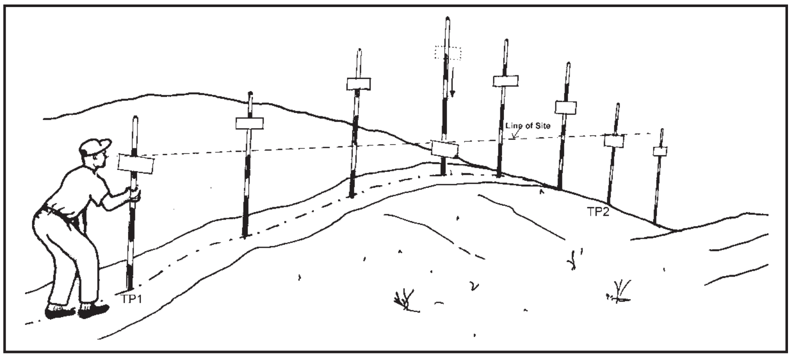


FIGURE 11 – E1.5: DETERMINING THE MID POINT OF THE CREST CURVE



3. Choose the appropriate **K value** from the table below and multiply it by the algebraic difference between the two gradients (**p** and **q**) of the two straight grades to get the minimum length of the vertical curve. Then choose L (length of vertical curve) to be a multiple of 20, if possible, for ease of setting out. Curve length L = K x (p - q)

TABLE 2 – E1.5: K VALUES FOR CREST CURVES

	Flat Terrain			Rolling Terrain			Hilly Terrain		
	Design speed			Design speed			Design speed		
	50	60	70	40	50	60	30	40	50
Crest curve K value (for safe stopping sight distance) (m)	12	20	35	8	12	20	5	8	12
Crest K value (for comfort)	2.5	4	5	1.5	2.5	4	1	1.5	2.5

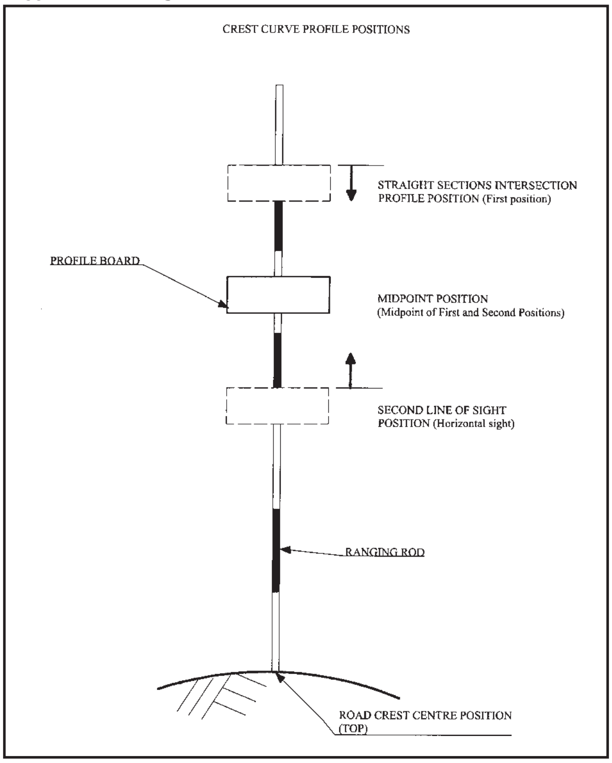
4. Measure both ways from the point **IP** a horizontal distance equal to half of the curve length (L) and fix ranging rods at both the beginning and end points of the vertical curve on the centerline (i.e. fix points TP_1 and TP_2).

5. Place profile boards on the two ranging rods at the beginning and end of the curve (i.e. points TP_1 and TP_2). Set the profile boards at each point to 1m above the desired road level.

6. Take a line of sight of string line over the top of the profiles at the two tangent points, and adjust the profile board at **IP** such that its top is in this line of sight (see **Figure 11** and **Figure 12** of **Section E1.5**). Put a chalk mark or a second profile board on the ranging rod at **IP** to mark the point at which the line of sight from TP_1 to TP_2 crosses this rod (at **IP**).

Note: The original level of the profile at IP must also be marked before moving the profile board up.

FIGURE 12 – E1.5:

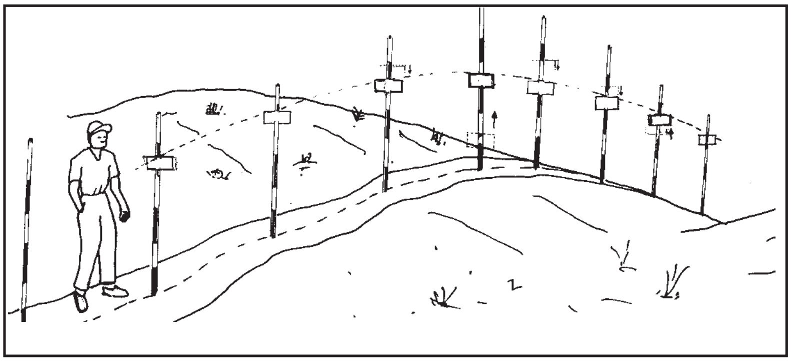


7. Measure the distance between the two marks on the rod at **IP** and halve it. Measure out the halved distance from either of the marks to mark the midpoint of the two. Fix a profile board at this new mark.

8. Adjust the remaining intermidiate profile boards between the two TPs keeping the profile board at **IP** fixed as shown in step 7. With the three profile boards fixed (i.e. the two TP and **IP**), the remaining profile boards should make a smooth curve. (See **Figure 13-E1.5**)

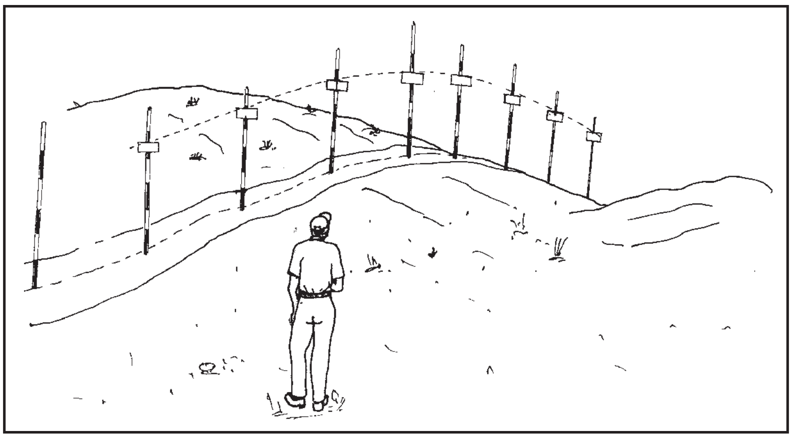
9. Run a string above the profile boards to form a curve. Walk away from the TP and look again at the curve, check that the adjusted profiles form a smooth a curve. If not, make necessary slight adjustment as appropriate.

FIGURE 13 – E1.5: SIGHTING AND ADJUSTING INTERMEDIATE PROFILES



11. Check if the curve set out complies to the minimum sight distance for standard design (as described in **Section B2**). If not, make slight adjustment as may be appropriate.

FIGURE 14 – E1.5: ADJUSTED PROFILE BOARDS.

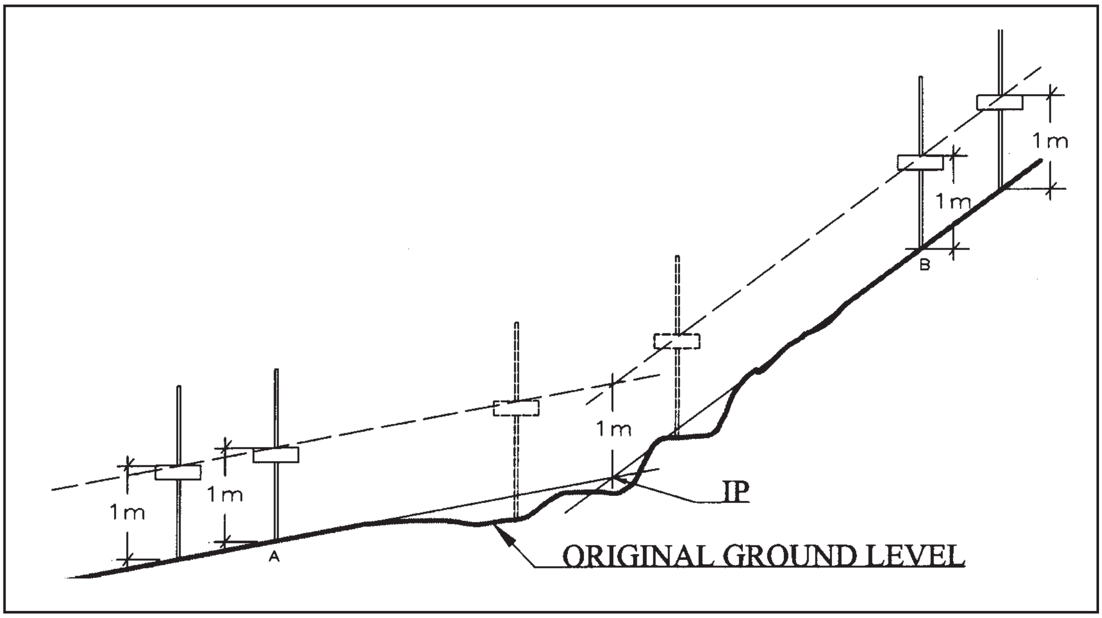


SETTING OUT SAG/CREST VERTICAL CURVES (ADVANCED PROFILE METHOD)

This method uses the basic vertical curve properties explained earlier and makes reference to the **Figure 2-E1.5**. The steps to be followed in setting out vertical curves are described below:

1. Measure the gradients (**p** and **q**) of the two straight grades to be joined by following the procedure described in **Section E1.3** of this manual.

FIGURE 15 – E1.5: LOCATING IP



2. Locate the intersection point (**IP**) of the 2 straight grades. In the first instance, try to locate this point by running strings on top of the profiles on the two straight grades and marking the point where they meet. Sometimes, it may not be possible to locate **IP** in this manner due to the point being too high up in the air or too deep in the ground. When this situation occurs use the following procedure to locate **IP**:

   a. Choose any two points on the 2 straight grades, A and B respectively.

   b. Find the difference in height between the two points (h) as described in steps 1 to 6 of **Section E1.3**.

   c. Measure the horizontal distance between the 2 points (d).

   d. Apply the formula below to calculate the horizontal distance between A and **IP**.

$$\boxed{d_1 = \frac{(100h - qd)}{(p - q)}}$$

Where d_1 = Horizontal distance between point A and point IP

h = Difference in height between points A and point B. *If A is lower than B, then h is positive (+). If A is higher than B, then h is negative (-)*

d = Horizontal distance between points A and B

p = gradient (%) of initial straight grade

q = gradient (%) of final straight grade

e. Measure out the horizontal distance d_1 from A and locate the ranging rod at **IP** in such a way that it lies exactly on the horizontal alignment on which the two straight grades are located.

3. To avoid large volume of earthworks during construction, ensure that **IP** is located squarely on natural high and low points such as hill tops and valley bottoms by adjusting the straight grades. Also, try to adjust the straights such that I is located on a chainage point which is divisible by 10 for ease of locating the ranging rods.

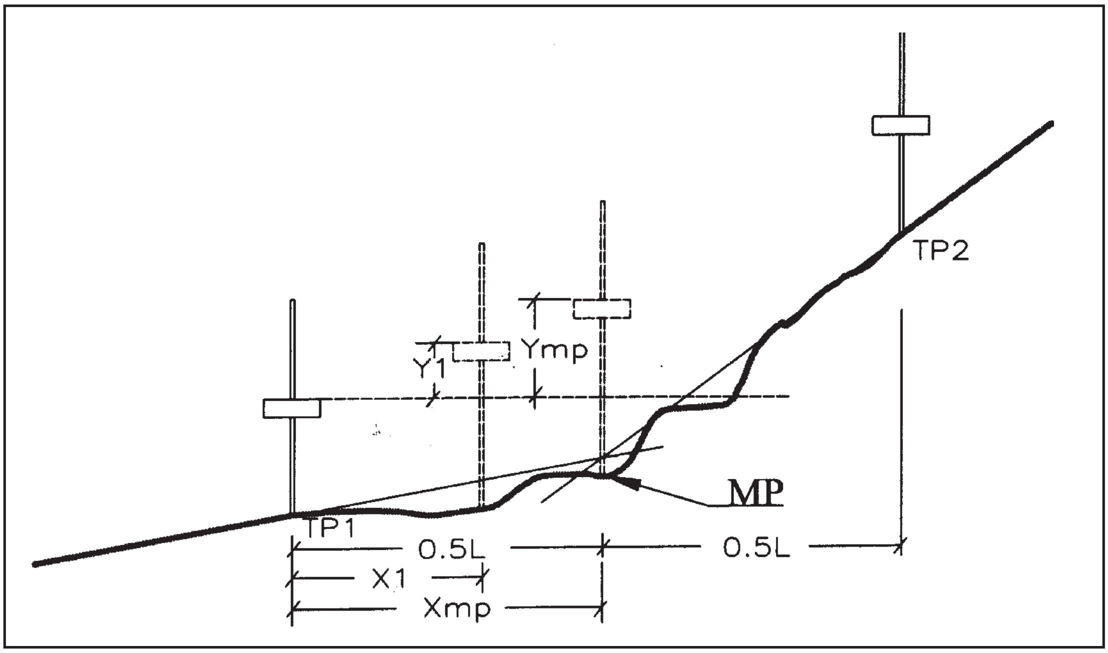
4. Choose the appropriate K value from **Table 2** in **Section B2.3** and multiply it by the algebraic difference between the two gradients (p and q) of the two straight grades to get the minimum length of the vertical curve. Then choose L (length of vertical curve) to be a multiple of 20 [i.e. 20 x (p + q)], if possible, for ease of setting out.

TABLE 3 – E1.5: K VALUES FOR SAG AND CREST VERTICAL CURVES

	Flat Terrain			Rolling Terrain			Hilly Terrain		
	Design speed			Design speed			Design speed		
	50	60	70	40	50	60	30	40	50
Crest curve K value (for safe stopping sight distance) (m)	12	20	35	8	12	20	5	8	12
Sag K value (for safe stopping sight distance)	12	18	25	8	12	18	5	8	12
Sag K value (for comfort)	2.5	4	5	1.5	2.5	4	1	1.5	2.5

5. Measure both ways from the point **IP** a horizontal distance equal to half of the curve length (L) and fix ranging rods at both the beginning and end points of the vertical curve on the centerline (i.e. fix points TP_1 and TP_2).

FIGURE 16 – E1.5: LOCATING TP AND ADJUSTING PROFILES



<u>NOTE:</u> There may be situations where it is not possible to set out vertical curves meeting the minimum curve length requirements. This happens when the distance between at least one of the adjacent grade intersection points (IP) is less than the recommended minimum curve length. In such situations, the curve length may be reduced to the largest length that can be squeezed in to allow sufficient space for the curve at the nearer adjacent IP. Such a curve will be <u>unsafe</u> and appropriate warning signs must be placed on both sides of the curve to alert motorists of the impending danger.

6. Place profile boards on the two ranging rods at the beginning and end of the curve. Set the profile board at beginning of curve (TP_1) to 1 m above the desired road level. Use this profile level as the datum level.
7. Place ranging rods with profile boards on the road centerline at 10m intervals in between the ranging rods at beginning of vertical curve TP_1 and end of vertical curve TP_2.
8. Using the level of the profile at TP_1 as the datum, calculate the levels above this profile for the rest of the profiles on the curve using the formulae:

$$\boxed{y = ax^2 + bx}$$

Where $$\boxed{a = \frac{q - p}{200L}}$$

$$\boxed{b = p\,\%}$$

It is advisable to calculate the levels of the points MP (curve midpoint at **IP**) and TP_2 (the end of the curve) first and fix them on the respective profile boards in order to have an idea of how the curve will look like before calculating for the rest of the points. (In fact from this point it is possible to set out the rest of the curve by eye).

The levels are best calculated in a tabulated form as shown in the two examples in the tables below.

A crest vertical curve has the following parameters:

p = 3 %

q = -5 %

L = 200 m

Therefore, a = -0.0002

and b = 0.03

TABLE 4 – E1.5: EXAMPLE OF A SAG VERTICAL CURVE

x	ax²	bx	y
0	0	0	0
20	0.095	-1.2	-1.105
40	0.380	-2.4	-2.020
60	0.855	-3.6	-2.745
80	1.520	-4.8	-3.280
100	2.375	-6.0	-3.625
120	3.420	-7.2	-3.780
140	4.655	-8.4	-3.745
160	6.080	-9.6	-3.520
180	7.695	-10.8	-3.105
200	9.500	-12.0	-2.500

9. Fix the profile boards on all the ranging rods at level y above the level of the profile board at point TP_1 using the method of establishing new levels described in **Section E1.3** of this manual. The levels may also be fixed using a simple levelling machine and staff.

Note that a negative (-) value of y simply means that the level is below the profile board at TP_1

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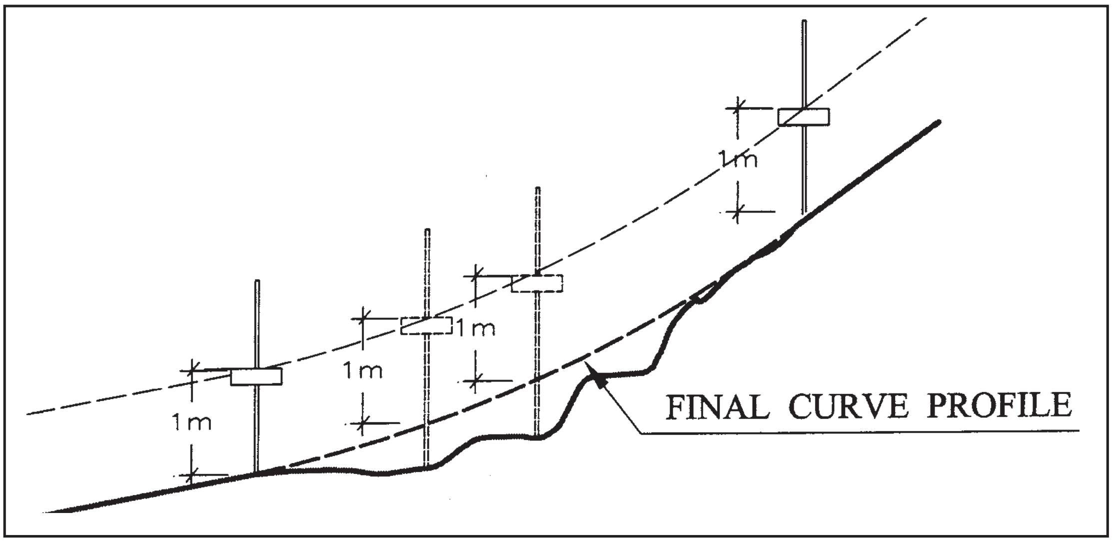
10. The tops of the profile boards should now form a smooth vertical curve. The required levels of the curve are now 1m below the tops of these profile boards.

FIGURE 17 – E1.5: FINAL CURVE PROFILE



A sag vertical curve has the following parameters:

p = -6 %

q = 3.5 %

L = 200 m

Therefore, a = 0.00024

and b = -0.06

TABLE 4 – E1.5: EXAMPLE OF A CREST VERTICAL CURVE

x	ax^2	bx	y
0	0	0	0
20	0.095	-1.2	-1.105
40	0.380	-2.4	-2.020
60	0.855	-3.6	-2.745
80	1.520	-4.8	-3.280
100	2.375	-6.0	-3.625
120	3.420	-7.2	-3.780
140	4.655	-8.4	-3.745
160	6.080	-9.6	-3.520
180	7.695	-10.8	-3.105
200	9.500	-12.0	-2.500

E1.6 SETTING OUT CROSS SECTIONS

CROSS SECTION ELEMENTS TO SET OUT

The cross section of the road to be set out should be selected according to the classification standards for district roads described in **Section B** of this Manual. The cross section dimensions may however change according to the design of the engineer.

The following elements are the cross sectional elements that require to be set according to the standards described above:

- Road carriage way width - depending on the design.
- The **Right-of-Way** - i.e the road reserve to meet future needs of expansion or right of way during construction.
- Formation width - to include carriage way and shoulders.
- Superelevation and widening at bends.
- Drainage widths and levels including side drains and slopes.

Setting out cross section width

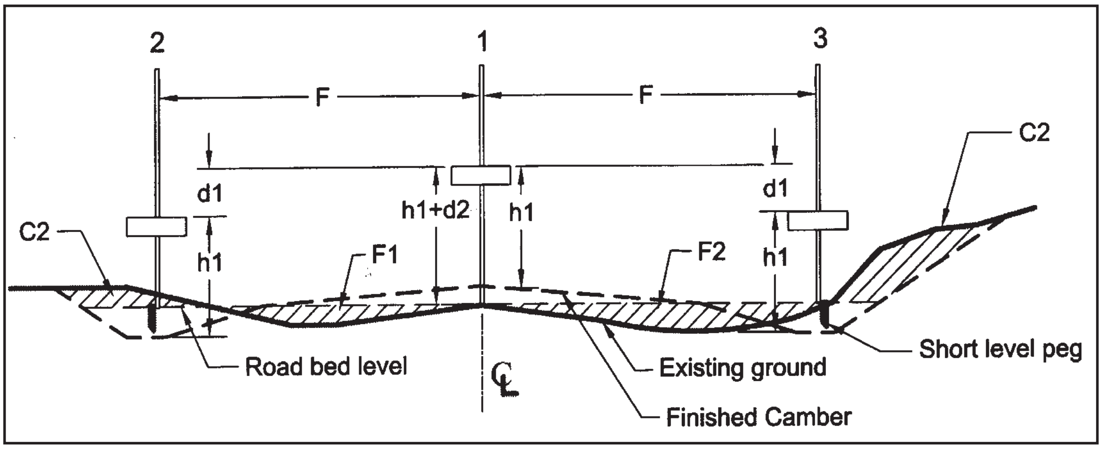
All cross section widths will be offset from the road centreline using a tape measure. Each measurement must be shown using pegs driven into the ground at the correct distance.

Setting out cross section levels

This will normally be limited to setting out of drainage (ditch) depths, fill thickness or superelevations, all of which are done by use of the method of transfer of levels described in **Section E1.3** of this manual.

The **Figure 1-E1.6** shows typical setting out of cross section levels. The procedure is described below:

FIGURE 1 – E1.6: SETTING OUT CROSS SECTION LEVELS



1. Fix bonning rod 1 at the centreline and rods 2 and 3 at centre ditch perpendicular to the centre line through rod 1.
2. Secure profile at h_1 metres above finished camber at rod 1.

3. Transfer the level to rods 2 and 3. Secure profiles 2 and 3 at height d1 below profile 1, i.e. profiles 2 and 3 will be at h_1 metres above finished ditch level. Check that the line through profiles 2 and 3 is horizontal.

4. Road bed level is $(h_1 + d_1)$ below profile 1 and $(h_1 + d_2 - d_1)$ metres below profiles 2 and 3.

5. Check for balance of cut and fill so that $C_1 + C_2 = F_1 + F_2$. The volumes of cut and fill along a cross section are approximately or nearly equal except when cut to spoil.

E1.7 OTHER SETTING OUT

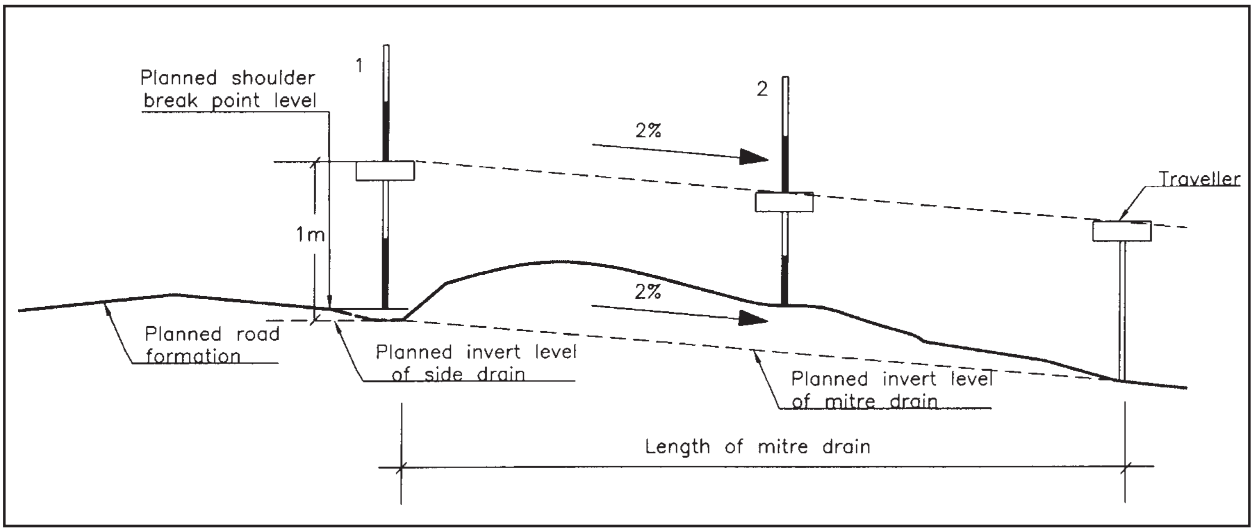
CHECKING THE LENGTH OF MITRE DRAINS

Locations of all outlet and mitre drains should be checked before the final roadbed level is decided upon. This should not come as an afterthought at an advanced stage of construction.

Referring to the diagram shown on **Figure 1-E1.7**, the steps to follow are outlined below:

1. Place boning rod 1 in the centre of the ditch at the turn out point for the mitre drain and rod 2 at 10 or 20 metres down on the centre line of the drain.
2. Adjust the profile on rod 1 to 1m above the drain invert level and set out the specified gradient to the profile at rod 2. (See **Section B5** for the specified gradients).
3. Sight over the profiles while an assistant moves a travelling rod on the ground along the drain centre line away from rod 2. The traveller rod is a ranging rod with a profile board set at 1m above the end of the rod touching the ground.
4. The end of the mitre drain is found where all the 3 profiles are flush when sighting through them from one end.
5. Measure the distance between rod 1 and the traveller. If the length of the mitre drain is more than 30m, then try to shorten the length by increasing the gradient. If this is not possible, raise the roadbed level or find another location for the drain.

FIGURE 1 – E1.7: CHECKING THE LENGTH OF MITRE AND OUTLET DRAINS



SETTING OUT CULVERTS AND OUTLET DRAINS

Referring to the diagram shown in **Figure 2-E1.7**, the procedure to follow when setting out culvert and outlet drains is outlined below:

1. Place ranging rods 1 and 2 (with profile boards) on the intended centreline of the culvert at both the shoulder break points. Rod 1 is on the inlet side of the culvert. The horizontal distance between the two rods should be 5.4m for cross section A.

2. Adjust the profile board on ranging rod 1 to 0.5 metre above roadbed level and calculate h_1. The level h_1 is the distance from the top of profile 1 to the underside of the culvert pipe in place. For cross section A using a 600mm diameter pipe culvert, the calculation will be as follows:

Height of profile 1 above shoulder break point	=	0.50 m
Minimum backfill cover	=	0.45 m
Outside diameter of 600 mm diameter pipe	=	0.72 m
Total depth (h_1)	**=**	**1.67 m**

3. Set out the culvert invert gradient from rod 1 profile board to rod 2 and adjust the profile board at 2 accordingly. Note that the culvert invert gradient should be between 2 and 4 % to avoid silting problems. Try for 4 % in the first instance in hilly terrain and 2 % in flat terrain.

   For cross section A in a hilly terrain, the difference in height between the profile boards on rods 1 and 2 shall be calculated as follows:

Level of profile 2 below profile 1	=	(4/100) x 5.4
	=	**0.22 m**

4. Take a third rod 3 and adjust the profile to height h_2 above the bottom end. The height h_2 is the height from the top of the profiles to the invert level of the outlet drain and it is calculated as follows:

h_2	=	h_1 – thickness of culvert pipe
	=	1.67 – 0.06
	=	**1.61 m**

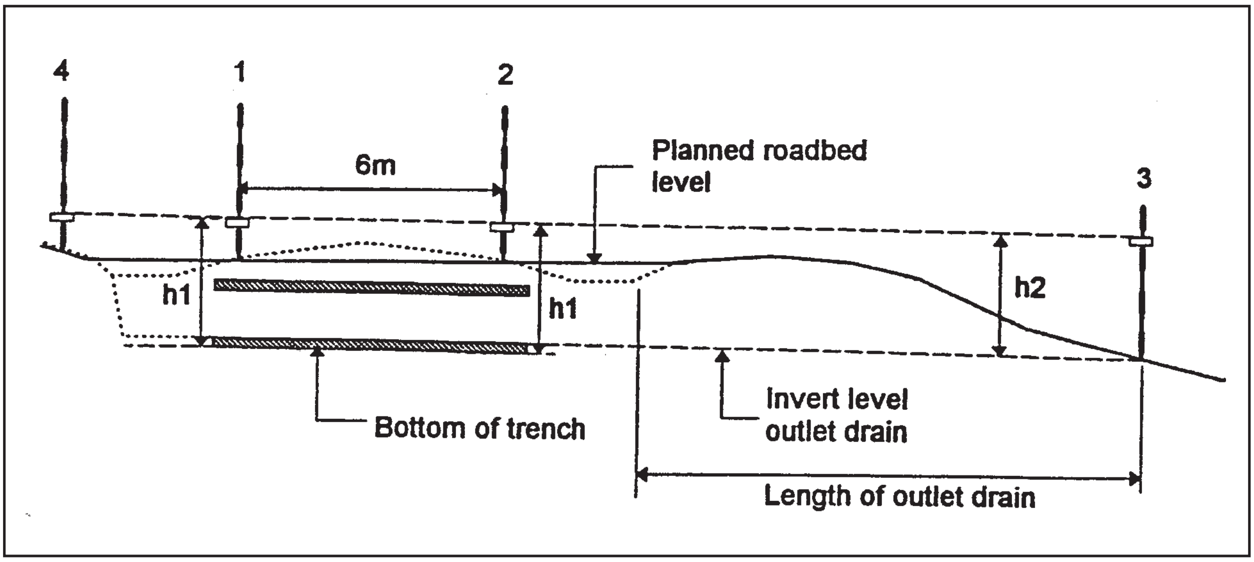
   Walk/move rod 3 along the centreline of the outlet until profiles 1, 2 and 3 are flush. Drive down rod 3 at this point and adjust the profile again flush with 1 and 2.

5. Measure the length of the outlet drain from the outer edge of the side drain.

6. If the drain is longer than 30m, reduce the invert gradient to not less than 2% and repeat steps 1 to 5.

7. In flatter areas, if the drain outlet cannot be found within 30m of the culvert outlet, then fix rod 3 at a distance 30m from the culvert outlet. Fit the rod with a second profile board (below the first one) and adjust the second profile board such that it is flush with profiles at 1 and 2. The difference in height between the tops of the two profile boards on rod 3 gives the level by which the road needs to be raised.

FIGURE 2 – E1.7: SETTING OUT CULVERTS AND OUTLET DRAINS



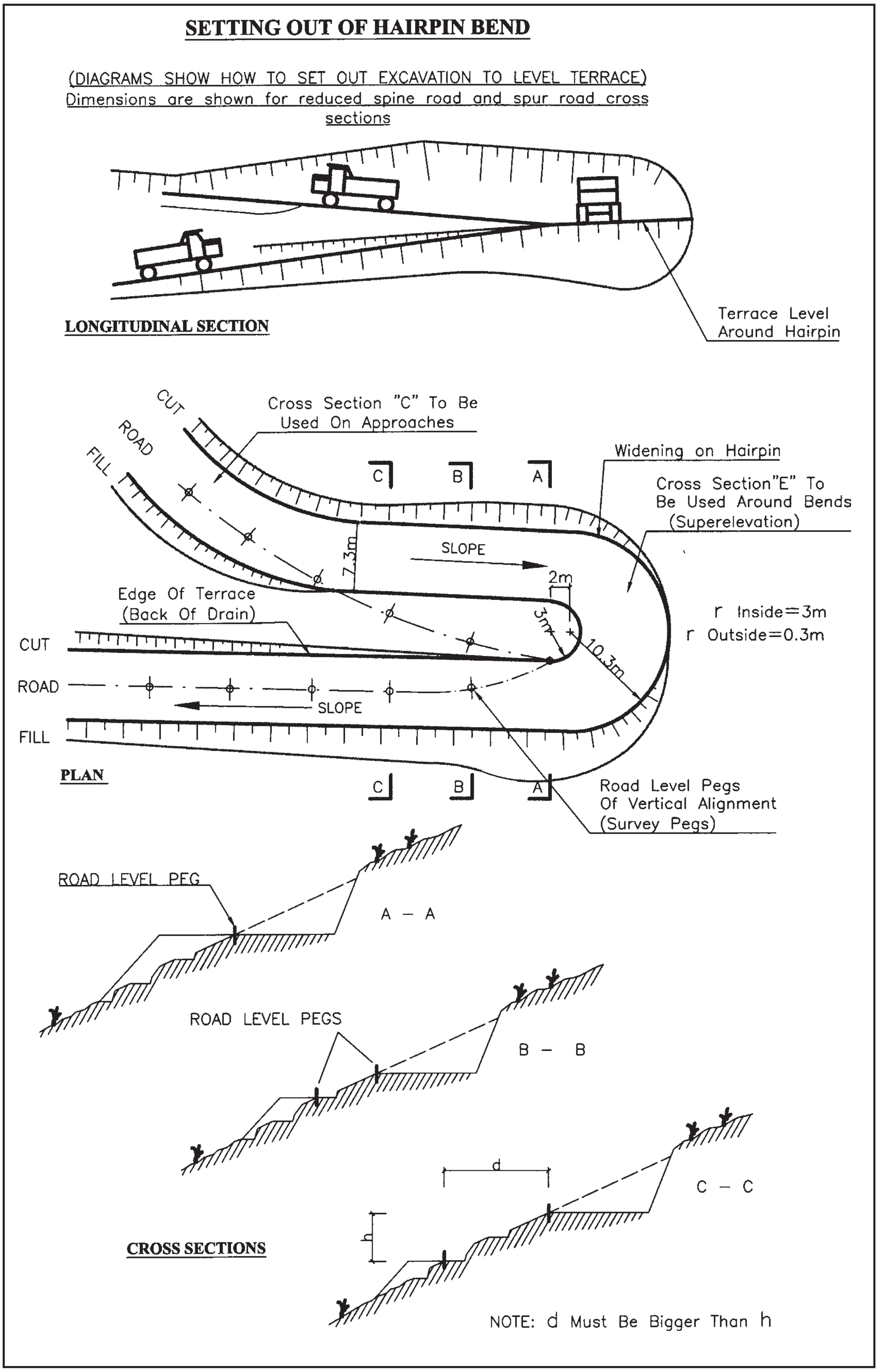
8. Drive down a peg to ground level at point 4 on the opposite side of the road as rod 3 (outside the working area). Fix rod 4 such that the profile board on it is flushing with 1, 2 and 3. Measure the distance from the ground peg at 4 to the top of the profile board and note down this distance. Point 4 shall be used as a control point for levels during the construction of the culvert.

9. Drivepegs at points 1, 2 and 3 such that the top of peg 1 is at the required level and the tops of peg 2 and peg 3 are at h_1 above the intended culvert invert level.

SETTING OUT OF HAIRPIN BENDS

Hairpin bends are sometimes necessary when the road alignment passes through very steep terrain. Their construction involves large volumes of cut and fill and therefore, their proper location is very important.

FIGURE 15 - E1.4: VIEWS OF A HAIRPIN BEND



The hairpin bend joins two sloping road straight grade sections but is nearly flat itself. This is necessary to provide a rest point for climbing or descending vehicles while they are negotiating the sharp bend.

Figure 3-E1.7 shows the longitudinal side view, plan and cross sections of a hairpin bend. The ranging rods which show the road levels are placed as shown during the vertical alignment. Point X is the intersection point, **IP**, or control point of the two level lines ZX and YX.

The following minimum standards for hairpin bends apply:

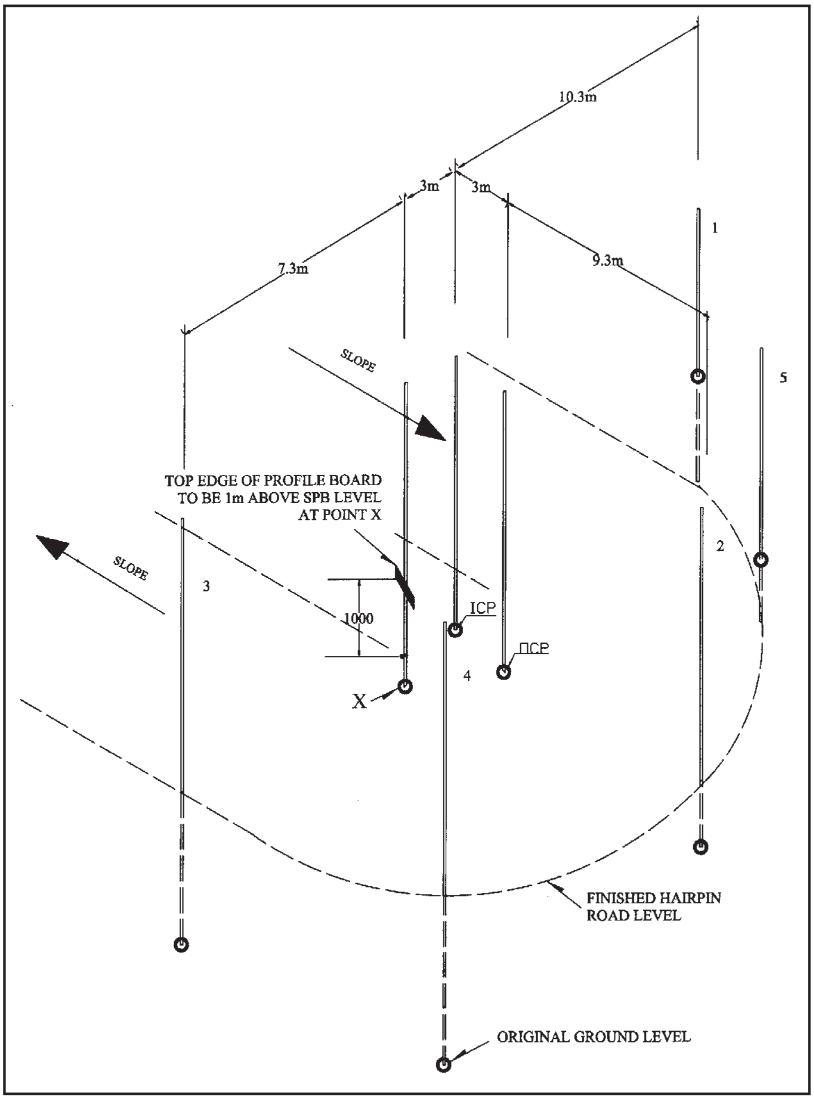
- The minimum radius of the inner curve is 3 metres
- The minimum radius of the outer curve is a minimum of 13 metres
- The crossfall throughout the hairpin bend shall be 5% one way (i.e. completely sloping towards the inside of the bend).

To provide more space for vehicles, the centres for the inner and outer curves are separated. For safety and good drainage, the outer curve is set out to be higher than the inner curve.

Referring to diagrams in **Figures 3-E1.7** and **4-E1.7**, the procedure for setting out hairpin bends is described in the following steps:

1. After setting out the vertical alignment through the area proposed for the sharp or hairpin bend, study the geometry of the terrain to see if it is suitable for a hairpin bend. Ensure that there is sufficient room to safely construct the hairpin bend. Make adjustments to the vertical alignment if necessary to obtain the best location for this hairpin bend.
2. From the control point at X, locate the Inner Curve Point (**ICP**), 3m into the hillside from point X and place a ranging rod at this point.
3. The Outer Curve Point (**OCP**) is then located 3m away from and at right angles to the line joining point X with the **ICP** and place another ranging rod as shown in **Figure 4-E1.7**.
4. Place a profile board on the ranging rod at the **ICP** and level it so that the top edge is 1m above the shoulder break point level at point X.

FIGURE 4 - E1.7: SETTING OUT OF A HAIRPIN BEND



5. Measure a distance of 10.3m [i.e. (3 + 7.3) = 10.3] from the ranging rod at the centre inner curve point (**ICP**) and locate the first point (No. 1) into the hillside and fix a ranging rod in line with point X and the **ICP** as shown in **Figure 4-E1.7**.

6. Set out a line at right angles to the first line (i.e. **ICP** to 1), measure 12.3 metres and fix a ranging Rod 2.

7. Set out another ranging Rod 3, which is in line with the Rod 1 to **ICP**. This point should be 10.3m away from **ICP** and on the opposite side as Rod 1.

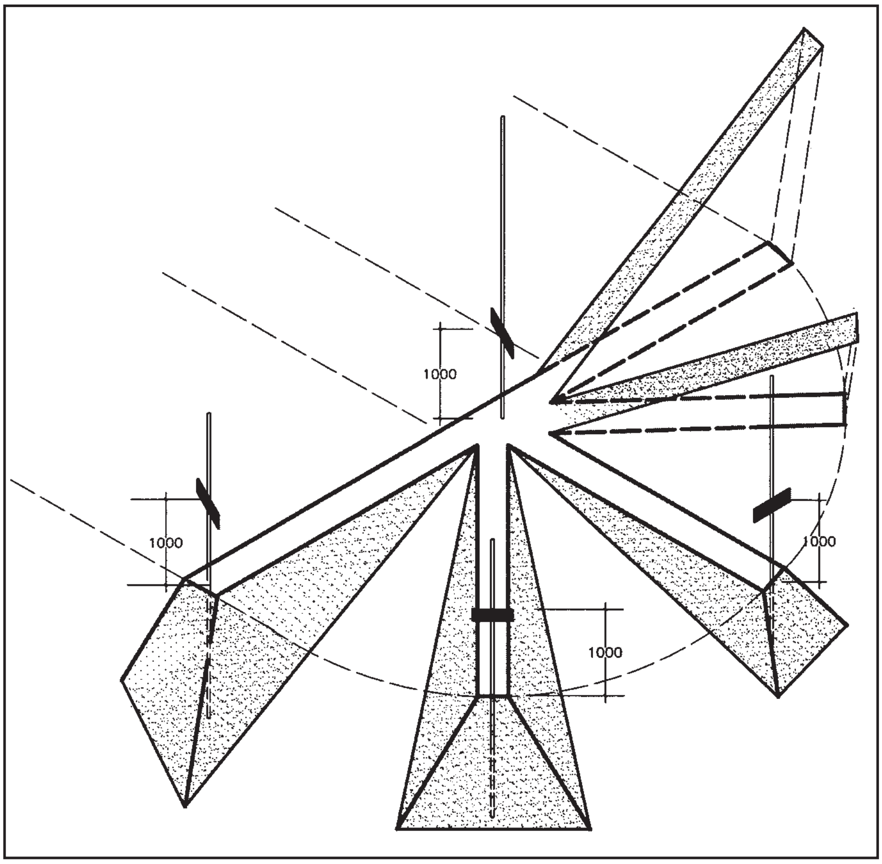
8. Locate the fourth point (4) in the direction between points 2 and 3 (by bisecting the angle), 12.3m away from **ICP** and fix a ranging rod (i.e. in the direction 45^{o} to **ICP**-2 or **ICP**-3) as shown in **Figure 4-E1.7**.

9. Locate point 5 in the same way as was described for point 4 in Step 8 but between Rod 1 and 2.

10. Using string and line level, adjust the profile heights on all the five ranging rods so that they are at the same height as the profile board on the ranging rod at **ICP**. Since the one way slope towards **ICP** is 5% over a distance of 13m, the profile boards at rods 1 to 5 should be raised by 0.65m.

11. Slots should now be formed on the five lines between the **ICP** and each of the five ranging rods. See **Figure 5-E1.7**. Note that all the slots are level from **ICP** to a point 3m away.

FIGURE 5 - E1.7: SLOTTING ON A HAIRPIN BEND



12. The transition from the 5% super elevation on the bend itself to the 8% camber on the straight grades should be phased in the same way as described for super elevations in **Section B2** of this manual.

13. Similarly, the width of the road should change from 13m (through the hairpin bend) back to the normal width for the chosen cross section uphill and downhill of the hairpin bend. This transition should be effected over a minimum length of 30m. Slots should, therefore, be constructed on both the uphill and downhill side of the hairpin bend to clearly guide workers on the details of the transition.

Section E2

Site Clearing

Section E2
Site Clearing

SITE CLEARING

Site clearance is the first operation in the construction/upgrading/rehabilitation sequence (after the alignment has been set out) and it is the removal from within the proposed road construction width of all bush, trees, boulders and organic matter including topsoil. This operation is undertaken to provide an obstacle-free road reserve on which subsequent operations can be easily undertaken. It enables one to see clearly what work needs to be done to construct the new road to the established design standards.

Table 1 – E2: Site Clearing Widths

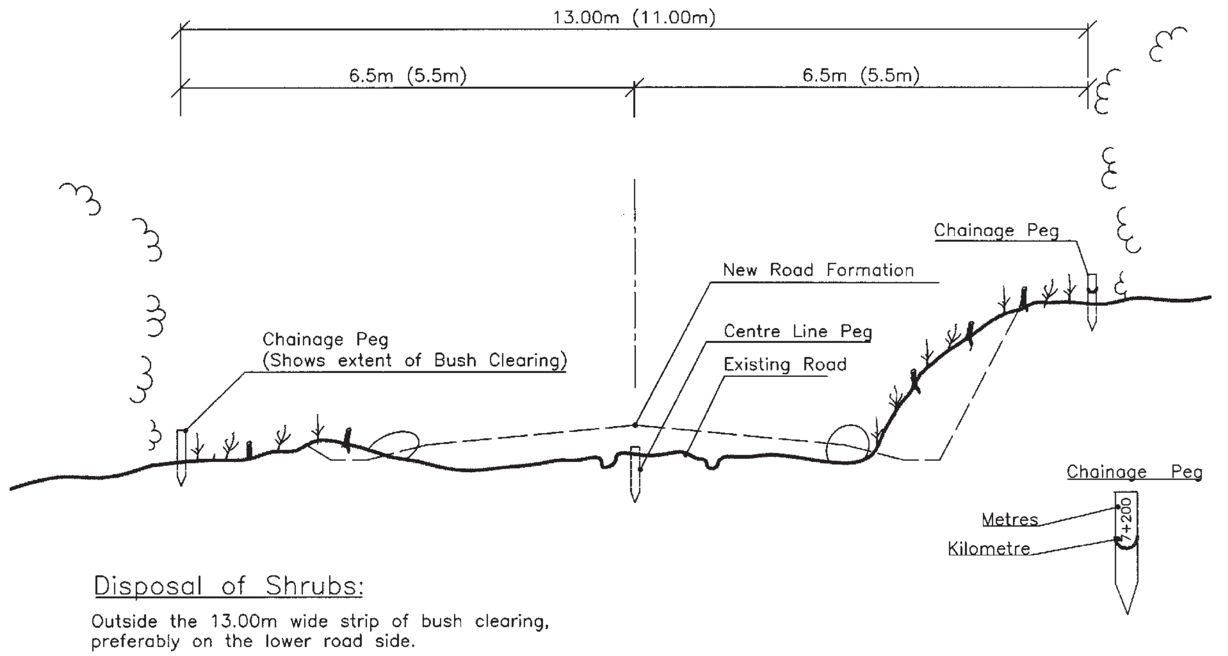
DISTRICT ROAD CLASS	CROSS SECTION TYPE	CLEARING WIDTHS (in metres)	
		CLEARING / TREE AND STUMP REMOVAL	STRIPPING / GRUBBING / BOULDER REMOVAL
CLASS I	1A (Standard)	15	13
	1B (Black Cotton Soil)	20	18
	1C (Embankment)	11 + (2 x embankment height)	9 + (2 x embankment height)
	1D (Superelevation)	17	15
CLASS II	2A (Standard)	13	11
	2B (Black Cotton Soil)	16	14
	2C (Embankment)	10 + (2 x embankment height)	8 + (2 x embankment height)
	2D (Superelevation)	14	12
CLASS III	3A (Standard)	11	9
	3B (Black Cotton Soil)	12	10
	3C (Embankment)	10 + (2 x embankment height)	8 + (2 x embankment height)
	3D (Superelevation)	12	10

E2.1 BUSH CLEARING

Definition

Bush clearing is the cutting and removal of all bushes, shrubs (maximum girth of 0.3m) and tall grass within the specified width and disposing of the cuttings outside the cleared area. The bush clearing widths for the various cross sections are shown in **Table 1-E2** of **Section E2**.

FIGURE 1-E2.1: BUSH CLEARING



NOTE: DIMENSIONS REFER TO CROSS SECTION 2A CLASS II (DIMENSIONS IN BRACKETS FOR CROSS SECTION 3D)

Resources

Tools

- Panga (Bush knife)
- Grass cutter (slasher)
- Bow saws
- Rakes
- Wheelbarrows

Labour

Sufficient labour must be available to ensure efficient cutting and clearing of bush and to exchange the work activities to reduce boredom and fatigue. The suggested minimum gang size is five labourers.

Productivity

The tasks are normally given out in terms of area (m^2). The task rates vary from $200m^2$ to $1000m^2$ depending on the density of the bushes.

TABLE 2 - E2.1: BUSH CLEARING TASK RATES

BUSH CLEARING	Average Productivity by thickness of vegetation in m^2 per worker day			Remarks
	Light	Medium	Thick	
Recommended task rate	1000 ~ 300 m^2/wd	250 m^2/wd	200 m^2/wd	Light: needs slasher or bush-knife Medium: needs bush-knife, bowsaw Thick: needs axe or chainsaw

Work Method

The bush is cut as close to the ground level as possible and the cuttings are deposited outside the cleared width. In certain cases, workers may execute this task in small teams with one or two workers cutting, and an extra worker disposing off the debris. This is normally the case when the bushes are very thick and the disposal area is a distance away.

The debris must be thrown outside the cleared width on the lower side of the road. In some situations the debris may also be piled and burnt in a controlled manner.

The labour productivities given in **Table 2-E2.1** apply for every worker in the gang irrespective of whether the workers are working individually (each worker cutting and disposing of debris) or as a gang (some workers cutting whilst others dispose of debris).

Quality Control

- The cleared area shall be free of all bushes, shrubs and tall grass. The width of bush clearing shall comply with the figures shown on **Table 1-E2**.
- At the end of bush clearing, the remaining vegetation shall not exceed a height of 10cm apart from the trees and/or stumps of at least 0.3m girth.

Environment, health and safety

- 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.
- Protective clothing in the form of gumboots, gloves and overalls will be required for the workers to protect themselves particularly from snake bites, insect bites/stings and scratches from thorns.
- Care must be taken to avoid damage to protected flora (vegetation), historical monuments and other heritage sites.
- A first aid kit must be readily available on site.

E2.2 STRIPPING AND GRUBBING

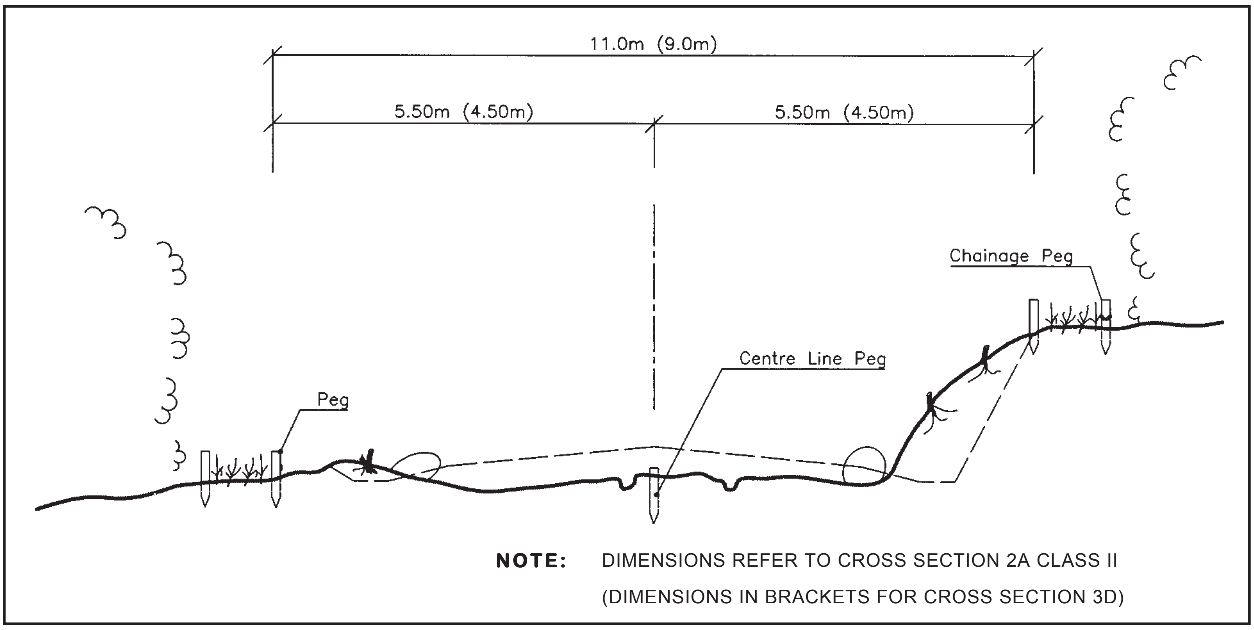
Definition

This activity follows immediately after bush clearing. It involves the complete removal from within the formation width of all remaining vegetation (other than trees and stumps) and unsuitable top soil. The top soil need to be removed only if it contains too much organic material or if it is unsuitable for road construction. The depth of the soil layer that must be removed can be estimated by examining how far down into the ground roots of grass, shrubs and small plants grow. The stripping and grubbing is normally done over the width that earthworks will take place.

Stripping and grubbing is done in order to:

- Remove organic materials and unsuitable soils from the construction area
- Expose stumps and boulders properly so that they are not overlooked in the next activities.

FIGURE 1-E2.2: STRIPPING AND GRUBBING



Resources

Tools

- Hoe (in soft soil)
- Mattocks (in hard soil)
- Shovel
- Rake
- Wheelbarrows

Labour

The gang size will be determined by the degree of ground cover and the applied task rate. With this activity, any number of workers can be applied to achieve the desired target.

Productivity

Task rates depend upon the thickness of the layer to be grubbed. The standard task rates vary from 150m² to 300m² per worker day.

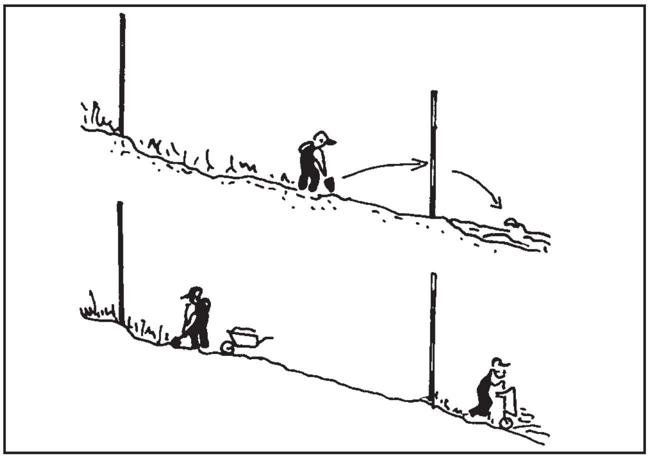
TABLE 1 – E2.2: TASK RATES FOR GRUBBING

GRUBBING	Average Productivity by thickness of grubbing in m² per worker day		Remarks
	Thickness up to 2 cm	Thickness over 2 cm	
Recommended task rate	150 m²/wd	300 m²/wd	The thickness of the grubbing or the density of grubbed area should be checked by the supervisor.

Work method

Workers must be well spaced out to ensure safety. Normally, each worker shall strip and grub over the full width of the road over the calculated length along the road. All workers work from one end of their respective tasks to the other. The workers need to be shown the extent of their task, how deep they should strip the soil, the length of the task and where they should dump the debris.

FIGURE 2 - E2.2: STRIPPING AND GRUBBING AND GRUBBING WORK METHOD



Each worker is shown the type of soil to be removed. It is recommended to use a wheelbarrow for disposing of debris unless the disposal area is within the shovel throwing distance.

The optimum efficiency on this activity is achieved if each worker is doing the entire task individually.

Quality control

- At the end of this stripping and grubbing, there shall be neither vegetation nor top soil containing organic material within the cleared width except for trees and stumps of 0.3m minimum girth.
- At any point along the road centreline, the cleared width shall comply with the values shown in **Table 1-E2**.
- The debris from this activity should be dumped and spread at locations where it will not be washed back into the road reserve during the rains. (i.e on the lower side outside the road)

Environment, health and safety

Ensure that:

- The debris is evenly spread at the dumping site to avoid trapping and channeling rain water thereby causing stagnant pools and/or erosion.
- Where the ground is too dry and prone to raising a lot of dust, water shall be sprinkled to minimize dust being inhaled by the workers. Alternatively, breathing masks shall be supplied to the workers.
- Workers must be well spaced out to ensure safety.
- A First Aid kit should be readily available on site in case of an emergency.

E2.3 TREE AND STUMP REMOVAL

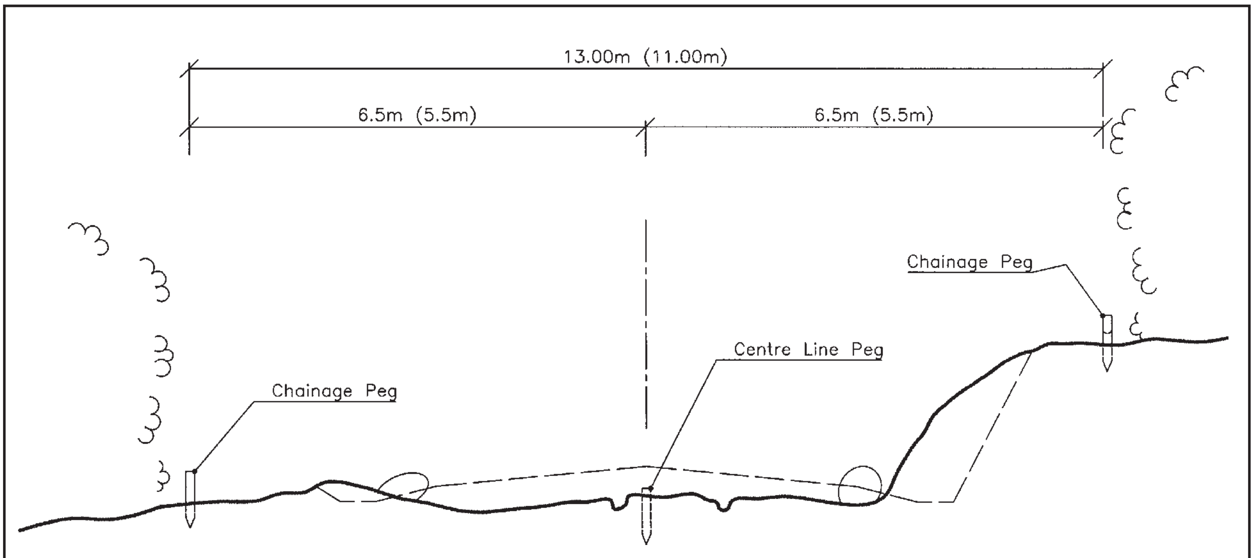
Definition

In road construction, a tree is a plant having a girth greater than 0.3m. The girth of a tree is measured as the circumference of the tree at a height of 1 m above the ground level. The activity includes felling the tree, uprooting its stump, cutting it up and disposing of the debris at an appropriate location. All trees are to be removed completely (including the entire root system) from within the bush cleared width.

Trees are removed to:

- facilitate the drying effect of wind and sun on the wet road
- provide good visibility to the traffic on the road
- avoid traffic hazards
- avoid structural damage of the road by expansion of roots
- have a strong subgrade free from rotting roots.

FIGURE 1-E2.3: TREE AND STUMP REMOVAL



NOTE: DIMENSIONS REFER TO CROSS SECTION 2A CLASS II (DIMENSIONS IN BRACKETS FOR CROSS SECTION 3D)

Resources

Tools

- Axe
- Bow saw
- Hand saw
- Pick
- Shovel
- Wedges
- Crow bars
- Rope

Labour

Sufficient labour must be available to ensure that the trees can be felled depending on workload.

Equipment

Chain saws may be used where it is necessary to increase the rate of cutting in order for the activity to keep up with other activities.

In situations where the extraction of stumps is difficult, a tractor may be used to help pull out the stump and roots.

Productivity

The task rate for cutting trees is highly variable owing to different types of wood, different types of root systems, different types of ground, etc. However, for guidance purposes, it is normal to use tasks rates of between 2 and 5 trees per worker day for small trees of girth 0.3m to 1m. For trees of girth more than 1m, it is difficult to predict the task rate and judgment based on local experience will be relied upon.

TABLE 1 – E2-3: TASK RATES FOR TREE AND STUMP REMOVAL

TREE AND STUMP REMOVAL	Average Productivity by girth of tree/stump measured at 1 m above ground in numbers of tree/stump per worker day			Remarks
	< 0.3 > 0.7 m	0.7 ~ 1.0 m	> 1.0 m	
Recommended task rate	5 Nos.	2 Nos.	daywork	The task rate varies according to type of trees, thickness of the branches. Judgement of supervisor is required.

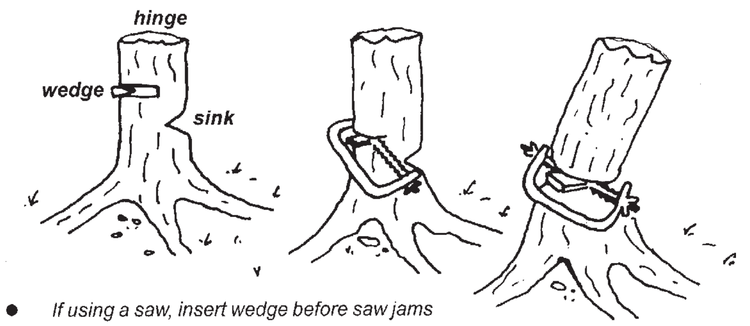
Work method

For small to medium size trees (girth of 0.3m to 1m), one of the easiest ways of felling these trees is by attaching a rope at least halfway up the tree and after excavating the ground from around the stump, have the gang (or tractor) pull on the rope. This will cause the tree to be uprooted with the advantage that the stump and most roots will come out of the ground simultaneously. This method is more efficient than cutting the tree first and digging the roots later. The remaining roots should be dug out of the ground.

If uprooting the tree as above is not possible because of the size of the tree, cutting and felling is required. The stump should then be uprooted by excavating the ground from around it. Depending on size and availability of resources, the stump may be pulled out intact by tractor or it may be chopped up and disposed of by labour.

After felling the tree, chop the tree up into manageable pieces and dispose of them outside the cleared width at an approved location.

FIGURE 2-E2-3 FELLING BIG TREES BY CUTTING



- *If using a saw, insert wedge before saw jams*
- *Cut a felling sink in the direction you want the tree to fall*
- *Make a felling cut with a cross cut saw opposite and above the sink*
- *Continue saw cut until tree begins to fall. Then stand away*
- *Make sure the tree falls in the direction you want it to, by using a wedge*

Quality control

- The cleared width (as given in **Table 1-E2**) shall be completely free of trees, stumps and roots.

Environment, health and safety

Tree felling is a highly dangerous activity and extra attention should be paid to safety as follows:

- When using the rope method, 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.
- With both the methods, make sure the area or circle on which the tree is intended to fall is well clear of people.
- Tree felling should not be attempted when there is strong wind.
- A first aid kit should be available on site in case of an accident.

The following environmental issues should be taken into consideration:

- Proper disposal should be adhered to in order to avoid littering.
- The depressions caused by uprooting large tree stumps (if they fall outside the formation width) should be backfilled.

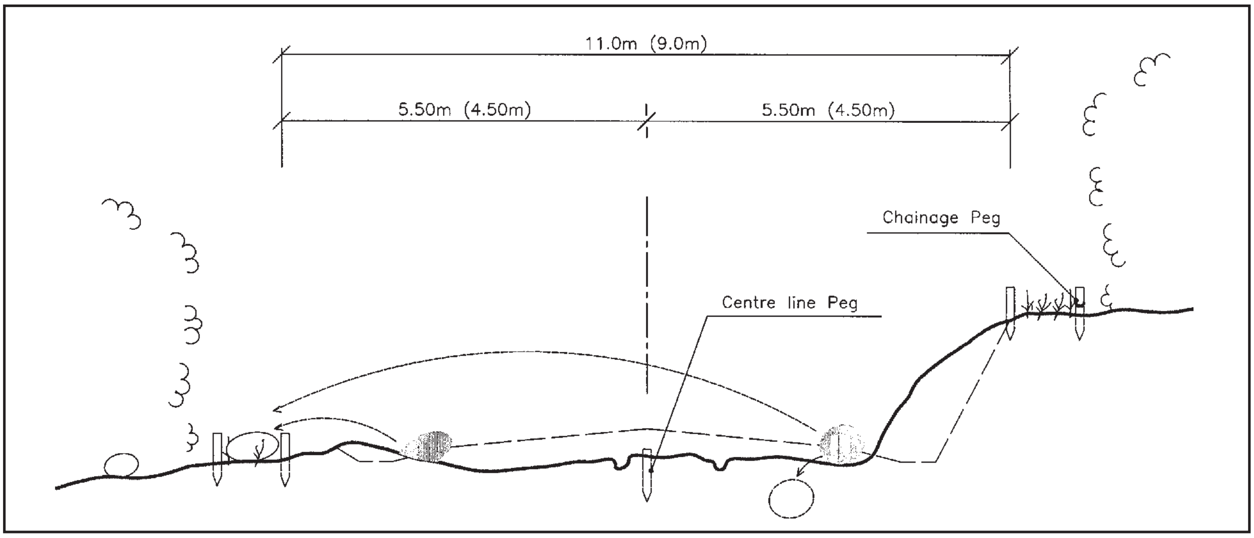
E2.4 BOULDER REMOVAL

Definition

Boulder removal activity involves the removal of large stones or boulders from within the cleared width of the road in accordance with **Table 1-E2**, and their disposal at suitable and approved locations.

Note This activity only covers the surface boulders that need to be removed to clear the road of obstacles.

FIGURE 1-E2.4: BOULDER REMOVAL



Resources

Tools

- Pick
- Shovel
- Crow bar
- Sledge hammer
- Safety goggles
- Hard hats
- Gloves
- Rope
- Wedges
- Feathers and plugs
- Watering cans
- Wheelbarrows

Labour

Gangs can vary from a single person to as many as 10 people working on a single boulder. A few rules exist, except those of experience and common sense, because it all depends on the quantity of boulders to be removed. However, too many people lead to inefficiency and vulnerability to serious accidents.

Equipment

Where boulders are too large for people to handle within the required time, the following equipment may be used:

- A tractor may be used to pull or push the boulder out of the cleared width. However, it must be borne in mind that tractor time is very expensive and, therefore, its use should be limited to deserving situations only.
- A compressor with a jack hammer or explosives may be necessary where the boulders are even too large for the tractor to pull or push.
- A vehicle jack may be used to assist in moving/lifting the boulder.

Productivity

For boulders up to 1.5m maximum girth (about 0.5m diameter), the task rates are between $2m^3$ and $4m^3$ (30 to 60 wheelbarrows) per worker day. These boulders are generally easy to physically handle by one or two workers.

Practically, where the volume of the surface boulders is less than $0.5m^3$ in every 100m, it is normal to combine the removal of these small boulders with stripping and grubbing clearing as one activity and reducing the stripping and grubbing task by up to 10% depending on how densely the boulders occur.

TABLE 1-E2.4: TASK RATES FOR BOULDER REMOVAL

BOULDER REMOVAL	Average Productivity in m^3 per worker day	Remarks
Recommended task rate	$2 \sim 4$ m^3/wd (or) $30 \sim 60$ wheelbarrow load/wd	For boulders up to 1.5m girth using wheelbarrow. Judging on the hauling distance, use the appropriate rate.

However, with larger boulders (over 1.5m girth), it is impossible to set a reliable range of task rates as the variations are too great. It is therefore normal to undertake the task as '**dayworks**'. This means that the labourers will be timed to work for eight hours under tight supervision so that they produce as much as possible within that time.

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.

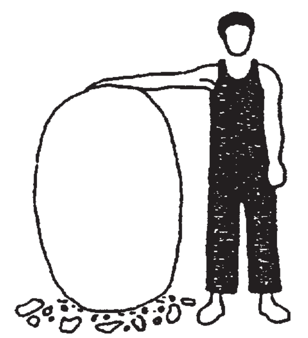
Moving the boulders out of the cleared width

Boulders may be carried, rolled, towed or pushed in the following ways:

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

The first 3 methods are very suitable for boulders of less than $0.5m^3$ in volume.

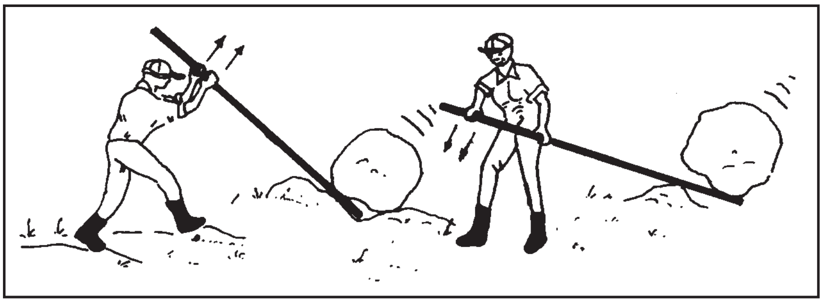
FIGURE 2-E2.4 BOULDERS THAT CAN BE MOVED BY LABOUR



CROWBARS CAN BE USED FOR BOULDERS UP TO THIS SIZE

Partially submerged boulders first have to be dug out before being moved. Pieces of rails can be placed under the boulder to provide a good surface to slide on.

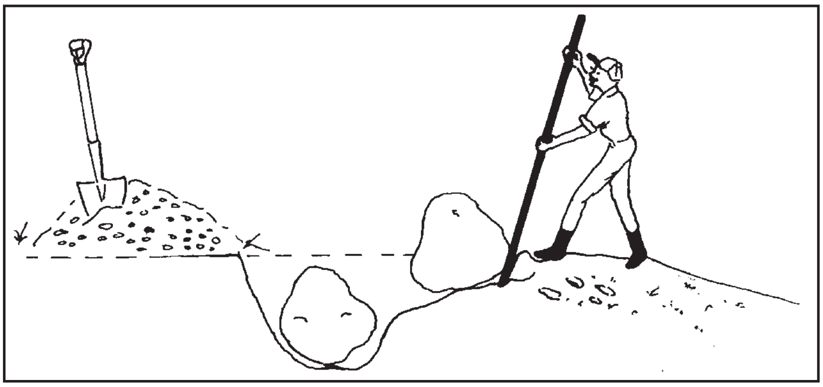
FIGURE 3-E2.4 BOULDER REMOVAL BY LABOUR USING CROWBARS



Burying boulders below the subgrade level

For boulders bigger than $0.5m^3$, and/or lying deeply embedded in the ground, digging a hole next to it and burying the boulder is often easier. It is necessary to first dig around the boulder in order to estimate its size and extent so as to decide on the best direction to dig the hole for burying it.

FIGURE 4-E2.4 BURYING BOULDERS BELOW SUBGRADE LEVEL



While pushing 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.

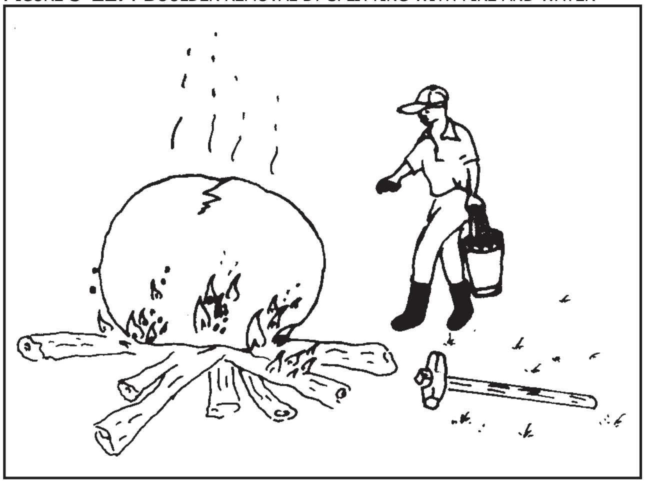
If boulders are too big or too deeply embedded to dig them out, it may be necessary to simply raise the road level such that the boulders are at least 0.2m below the subgrade level. A vehicle jack may also be used to jack and move the boulder

Splitting boulders using fire and water

An individual boulder or rock surface may be cracked by building a substantial fire around and/ or over it to heat it and rapidly cooling it with water.

The vegetation arising from other clearance activities may be used for firewood in this activity. The fire will need to be fuelled for a long period (at least 6 hours) to heat up and expand the rock sufficiently. This heating stage can also be done overnight to save on time.

FIGURE 5-E2.4 BOULDER REMOVAL BY SPLITTING WITH FIRE AND WATER



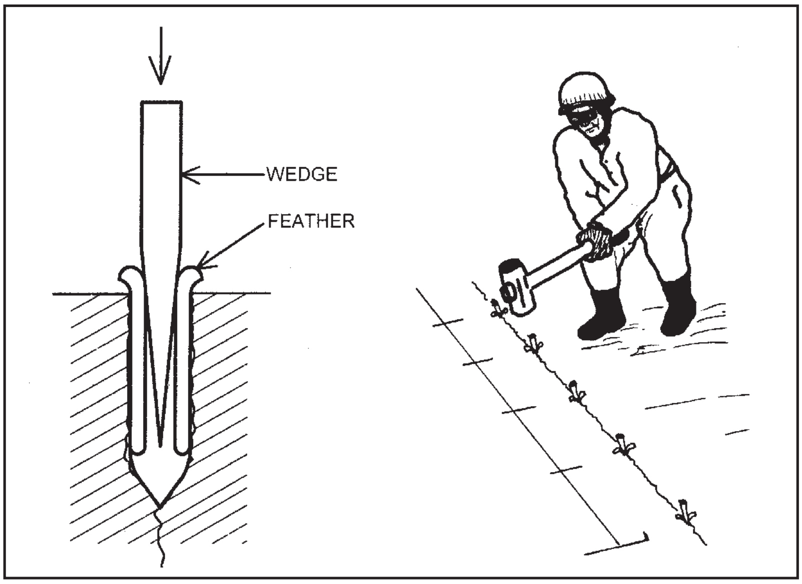
The boulder should then be cooled rapidly by dousing it with large volumes of water. The rapid cooling will cause shrinkage and cracking of the rock. Cracking may also be encouraged by striking the boulder with sledgehammers at this stage.

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.

Splitting boulders using hand tools

If the boulder or rock is weathered or cracked it is often possible to break it into smaller pieces using picks, sledge hammers with chisels and wedges or feathers and plugs. Feathers and plugs can be used in groups of four to break rock along a pre-determined line. Holes can be drilled in rock using hand quarry drills and sledge hammers. These (feathers and plugs) are then used for the splitting tools.

FIGURE 6-E2.4 USING FEATHERS AND PLUGS FOR SPLITTING BOULDERS



Splitting boulders using jack hammer

Boulders may be split using a jack hammer if the quantities of rock are large. The jack hammer uses compressed air from a compressor to break the rocks by striking them repeatedly. Since the jack hammer breaks rocks at a relatively fast rate, it is important to remove the split rocks as quickly as possible from the working area by having adequate labourers to clear the rocks.

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.

Quality control

- At the end of this activity, a visual check should be carried out to ensure that the cleared width (in accordance with **Table 1-E2**) is completely free of boulders.
- In the case where boulders are buried, check to ensure that they are buried well below 0.2m of the intended subgrade level.

Environment, health and safety

- When splitting rocks using hand tools, labourers must wear boots eye protection goggles 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.
- If pneumatic drills are to be used, then the labourers working with this equipment must be supplied with ear and eye protection gear including boots.
- Stones and boulders from this activity should not be disposed of in such a way that it blocks any natural waterways or diverts them.
- 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.

E2.5 OTHER CLEARING ACTIVITIES

REMOVAL OF ANTHILLS AND TERMITE WORKINGS

Definition

This activity involves the complete removal of all anthills and termite workings which occur within the formation width by excavation to full depth of the anthill.

Resources

Tools

- Pick, mattock or hoe
- Shovel
- Wheelbarrow
- Rammer

Labour

The labour required for this activity varies depending on the size of the anthill.

Equipment

- Roller

Productivity

The productivity in the removal of anthills and termite workings depends on the size and the extent of the termite workings.

Work method

The anthill or termite workings must be fully excavated. The material so excavated, including the debris from demolished anthills, shall not be used as part of the road structure. It shall be dumped well outside the construction width of the road.

The excavation shall then be rammed or compacted by vibratory roller to pre-collapse any sub-surface voids which may be present. The excavation should be backfilled with selected fill material in compacted layers not exceeding 0.15m loose thickness.

Quality Control

- Ensure that the excavation has been totally removed and the excavation has been rammed before backfilling the excavation.
- Check that none of the debris remains within the formation width of the road.

Environment, health and safety

- The depressions caused by the excavations (if they fall outside the formation width) should be backfilled.
- Under no circumstances should any chemicals be applied to anthills and/or termite workings. Excavation and removal from the formation width shall be adequate.
- Workers shall be provided with overalls, gloves and gum boots in order to offer some protection against bites and stings.
- A first aid box shall be readily available in case of an emergency situation.

Section E3

Roadbed and Formation

Section E3
Roadbed and Formation

ROADBED AND FORMATION

E3.1 EARTHWORKS

The earthworks operation involves using/moving earth to form the road to the required level. There are several situations that call for different ways of handling the earthworks. In all cases, the principal earthworks activities include:

- Measuring and calculation of volumes
- Excavation including cutting and borrowing to fill and/or cutting to spoil
- Loading, hauling and unloading (if required)
- Spreading and compaction

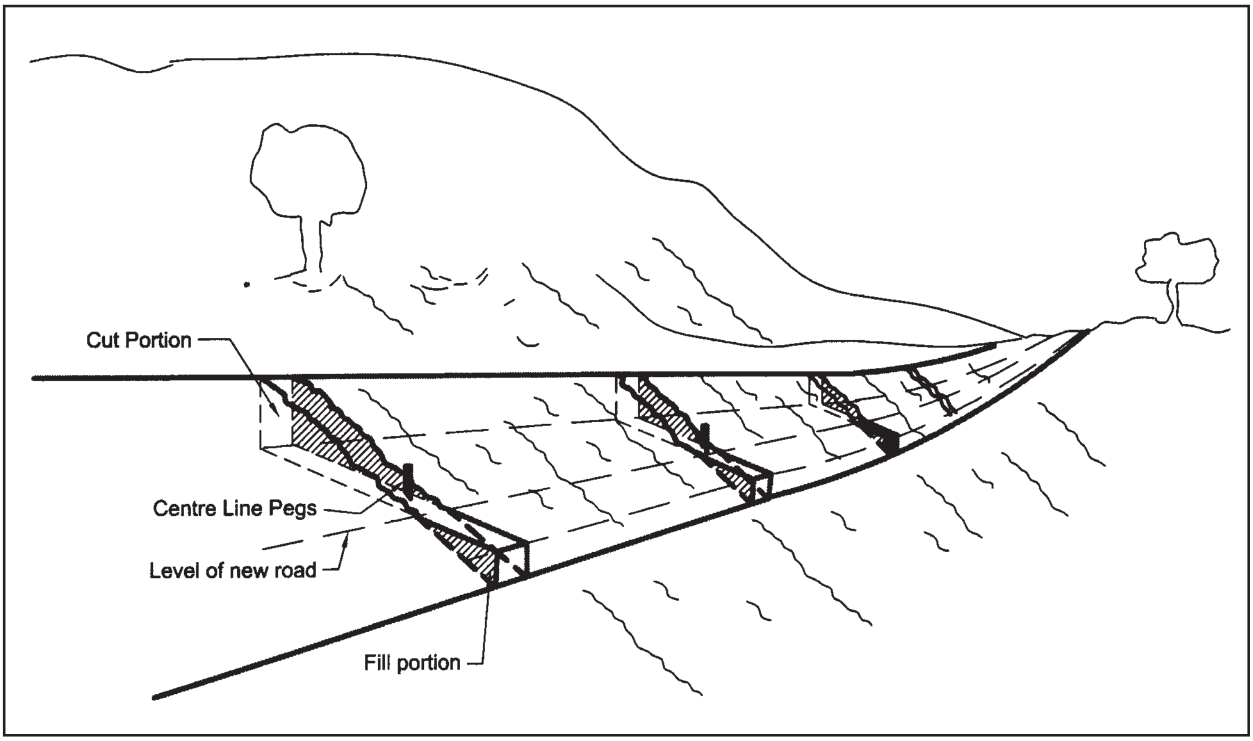
This section will deal with estimating the quantities and the distinct earthwork activities described in the following paragraphs.

Volume and Slots

Prior to any excavation of earth fill works, volumes must be determined in order to asses the resources needed for the works. This will involve carefully taking measurement and calculations. In order to get accurate measurements, the expected formation, road bed or drain levels after construction must be set relative to existing ground by use of slot (slotting) technique. (see **Figure 1-E3.1**)

When applied to the excavation to level technique, slots are used as a visual guide to the workers on the shape of the road bed that they are to construct. When applied to direct excavation of drains method (i.e. where excavation to level is not required), slots become a guide to ditch profile and levels. Slots are also used to expose the ground conditions where the construction activities are to take place. Slots must be

FIGURE 1 – E3.1: SLOTS FOR EXCAVATION TO LEVEL



compacted by ramming or ped rollers at optimum moisture content. The top of the slot should be 0.5m and the length depends on the road cross section. Slot levels must be set and adjusted by use of vertical alignment methods described in **Section E1.5**, to avoid excessive earth works or achieve a smooth profile.

The exposed cross section areas of the existing ground in between slots can be accurately measured and calculated using the following formula. Multiplying the average area with the length of work in successive slots give volume of earthworks.

$$\textbf{Volume of Earth between successive slots} = \frac{A_1 + A_2}{2} \times L$$

Where A_1 = Area of cut section in slot 1

A_2 = Area of cut section in slot 2

L = Distance between successive slots

For lower class roads (such as District Class III roads and community roads) the straightness of the vertical alignment becomes less important. In such roads, following the existing terrain to a great extent may be feasible. The most economic method of constructing such roads is by excavating the slots (for excavation to level) in such a way that cut and fill within the slot is balanced. This means that the excavated material from one part of the slot is just sufficient to fill the other parts of the slot in a lateral direction.

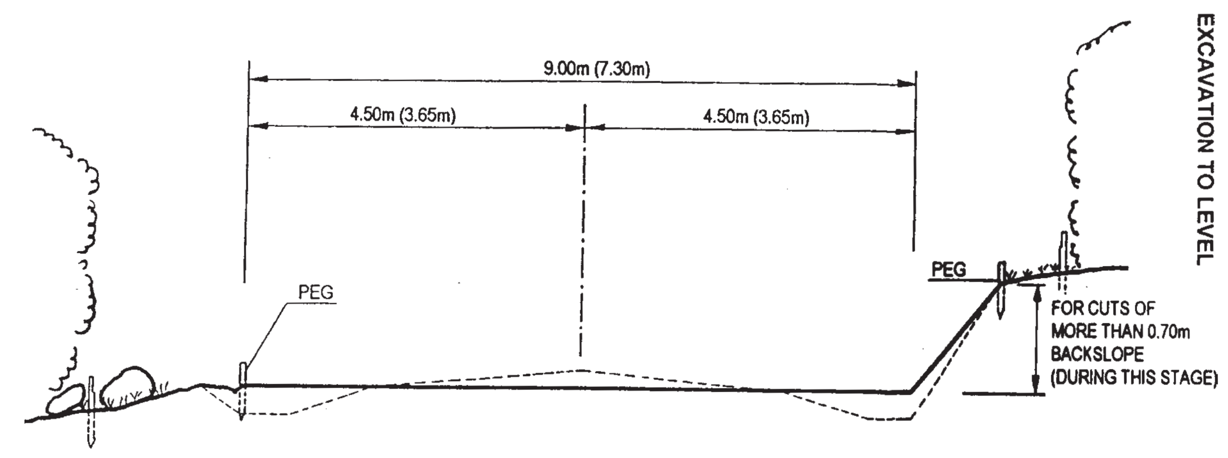
EXCAVATION TO LEVEL

Definition

Excavation to level is carried out to provide a level terrace, in accordance with the designed vertical alignment, on which the drainage and camber can be constructed in an accurate and controlled manner. The level of this terrace is the same as the subsequent level of the shoulder break point of the road. The width of the level terrace 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 centreline.

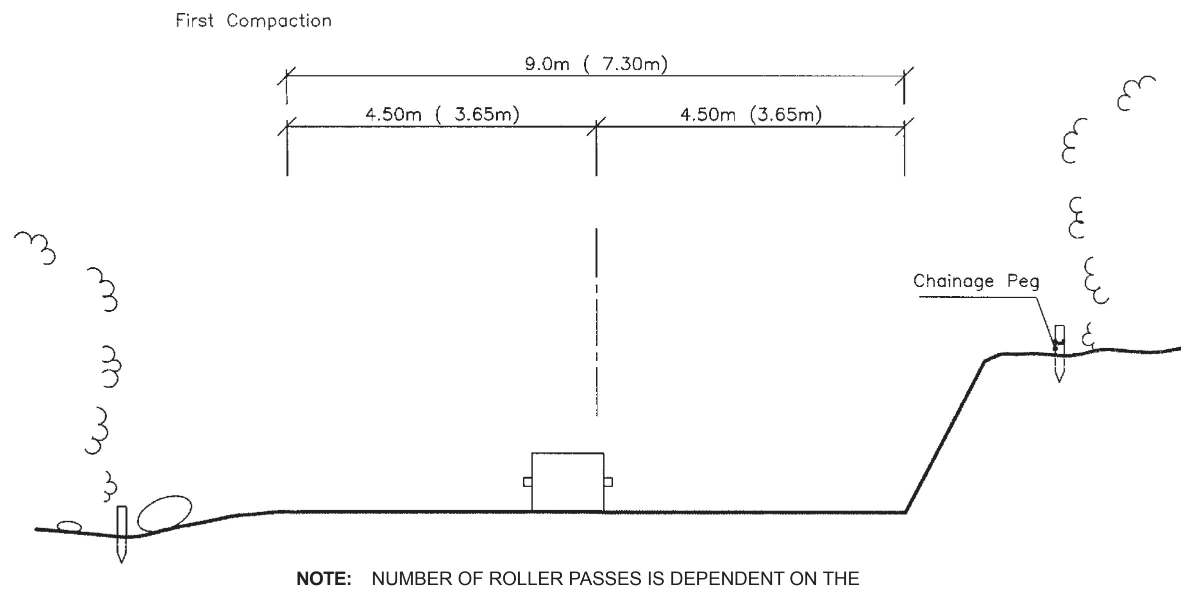
The extent of excavation to level is shown in figure below:

FIGURE 2 – E3.1: EXCAVATION TO LEVEL



NOTE: DIMENSIONS REFER TO CROSS SECTION 2A
(DIMENSIONS IN BRACKETS FOR CROSS SECTION 3D)

FIGURE 3 – E3.1: FIRST COMPACTION



NOTE: NUMBER OF ROLLER PASSES IS DEPENDENT ON THE REQUIRED SPECIFICATIONS

The profile levels or the slots act as a guideline for the excavation and filling of each 10m section of road to achieve a transversely level terrace. If the slots are constructed without longitudinal balancing or adjustment by profiles, then the excavation and filling between slots should be balanced. Where adjustments were made to the slots then additional excavation or filling may be required by lateral extension of the terrace, back sloping, longitudinal hauling by wheelbarrow or borrowing top soil.

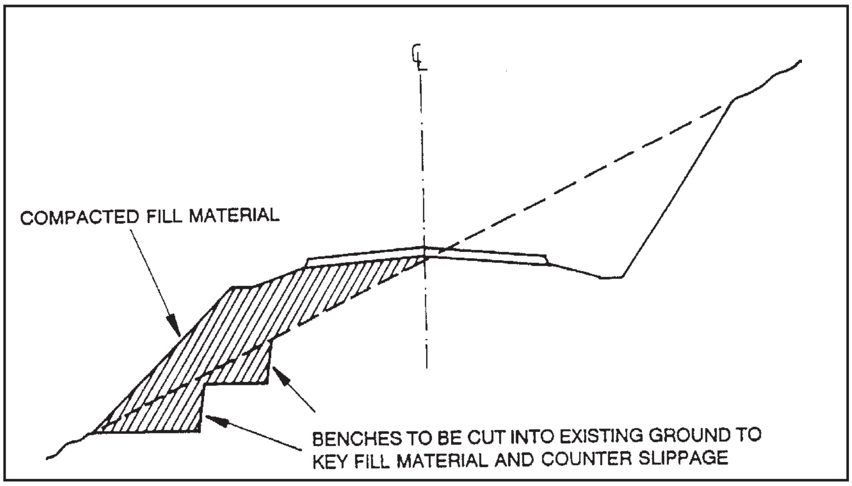
In all cases, compaction of the fill material will be required for the full width of the roadway to ensure that a stable bench or platform is achieved.

The fill material must be spread in thin layers maximum 15cm loose and compacted with a vibratory roller to avoid later consolidation. This is particularly important when the deepest fill occurs in the middle. The filling and compaction must be continued until the slot level is achieved.

On steep sidelong ground, there will be a potential hazard of fill material slipping down the slope. In this situation, benches should be cut into the existing ground under the toe of the fill to help anchor it.

It must be noted, however, that where the existing ground is already approximately flat and level and the straightness of the vertical alignment is not too important, excavation to level may not be required.

Figure 4 – E3.1: Keying fill into steep sidelong ground



Resources

Tools

- Pick or mattock or hoe
- Shovel
- Hand rammers
- Boning rods or ranging rods with profile boards
- Watering cans (for watering slots)

Labour

The gang sizes will be determined by the volumes of excavations involved on each day for both the slotting and the actual excavation to level.

Equipment

- Vibrating pedestrian roller
- Water bowser (where necessary, it can either be self propelled or tractor-towed)

Productivity

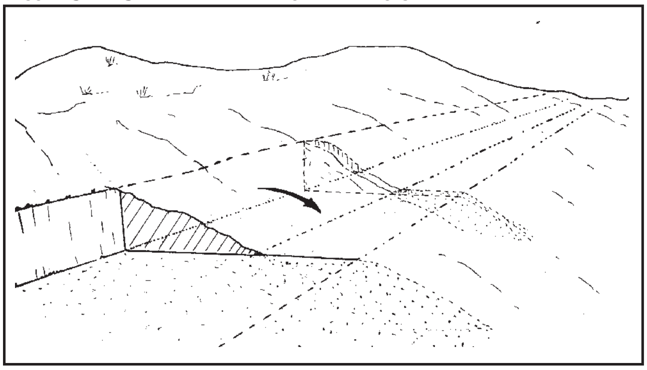
Please refer to **Tables 1~9-E3.1** under the Embankment section.

There are three situations that occur for the excavation to level.

Material exactly balances laterally

In this situation, material is cut from one side of the road bench and thrown to the other side where additional people then spread this material prior to its compaction.

FIGURE 5 – E3.1: MATERIAL EXACTLY BALANCES LATERALLY



The slotting for this activity is usually carried out on an individual basis and the task rate is dependent on the throwing distance of the excavated material. The task rates vary from 1.5m^3 to 2.0m^3 per worker day. This productivity takes into account that compaction for slotting is done using hand rammers and the watering is done by watering cans.

For joining up the slots by excavating to level in between the slots, the productivity varies from 2.5m^3 to 5.0m^3 depending on the type of material and the throwing distance. This productivity takes into account that the compaction is done by pedestrian roller assisted by a bowser for watering.

Equipment productivity will vary but the guidelines in **Tables 1~9-E3.1**.

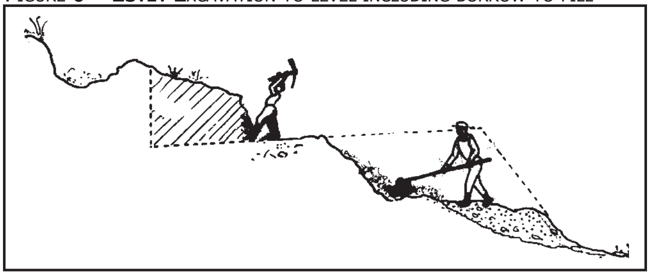
Excavation to level including borrow to fill

In this situation, although some material is cut to fill within the formation width, extra (borrow) material (from outside the formation width) is required to bring the roadbed to the required level.

The productivity for this activity depends on the haul distance of the borrow material, the type of equipment used (wheelbarrows, tractor/trailers or tippers) and the type of material hauled. This activity involves:

- Excavation of borrow material from the quarry
- Load and haul borrow material
- Offload and spread borrow material

FIGURE 6 – E3.1: EXCAVATION TO LEVEL INCLUDING BORROW TO FILL



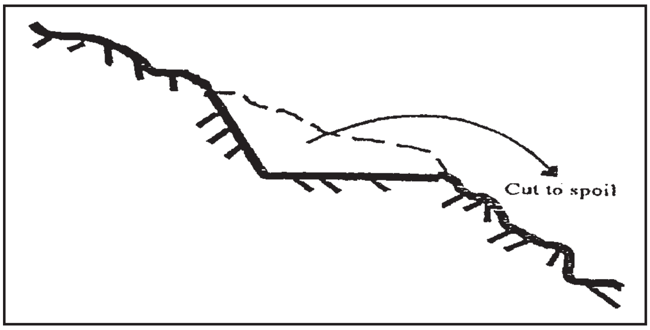
Cut to spoil

Here the cut (excavated) material is thrown out of the roadway. This is applied when the side long slope is too steep that it cannot safely support the fill material and/or cannot safely allow workers to work on it.

For this situation, the task rates of 2.5m^3 to 5.0m^3 apply depending on the throw distance and the type of material excavated.

Equipment productivity will vary according to the guidelines in **Tables 1~9-E3.1**.

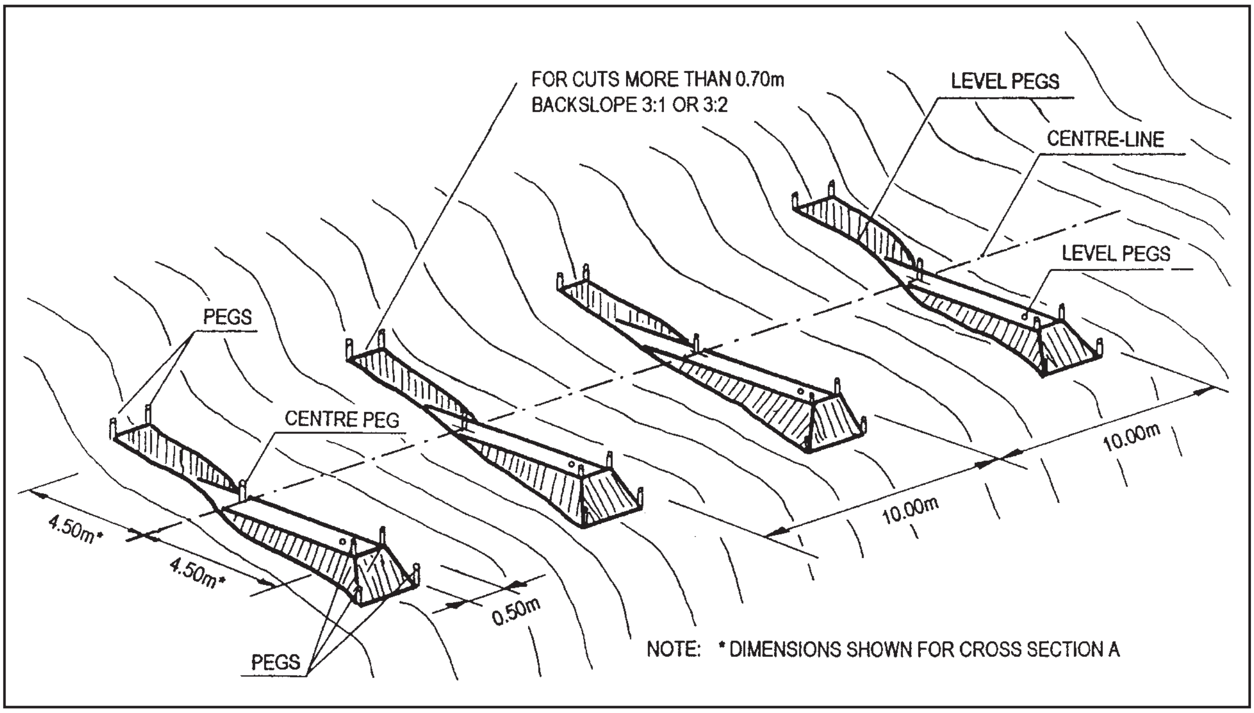
FIGURE 7 – E3.1: CUT TO SPOIL



Work method

Slotting is carried out as shown in **Figure 8-E3.1**. The slot interval along the road must be 10m. The slot is constructed as described in the earlier part of this section by cutting material from the high spots.

Figure 8 – E3.1: Slotting



Once the slots are ready, excavation to level can then take place to join up the slots. Guidance to the workers shall be provided by strings and pegs that will clearly demarcate the limits of excavation and extents of fill as shown in **Figure 10**.

To ensure proper compaction of the fill, the roller must be working in the same area as the people are working. The fill layers must be compacted by roller (self-propelled or towed) and the loose fill layers must not exceed 150mm loose. The fill layers must be watered where necessary) such that the moisture content at compaction is between 80% and 105%. A minimum of six passes of compaction shall be applied or until no roller imprint on the surface can be recgonised.

In high cuts, It is advisable to work in steps of 1 metre height and provide a bench for the next days' work as shown in **Figure 10-E3.1**.

Figure 9 – E3.1: Seeting out for excavation to level

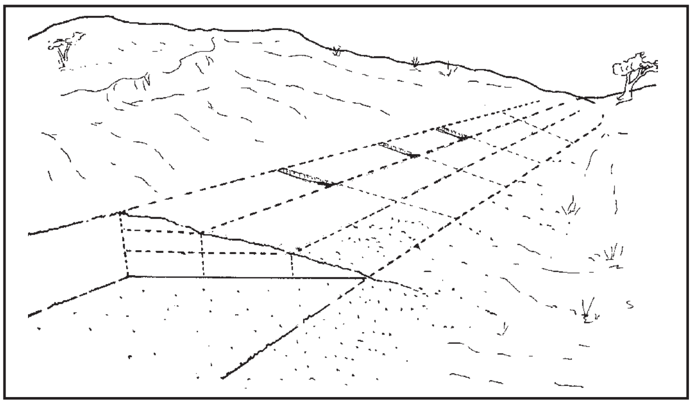
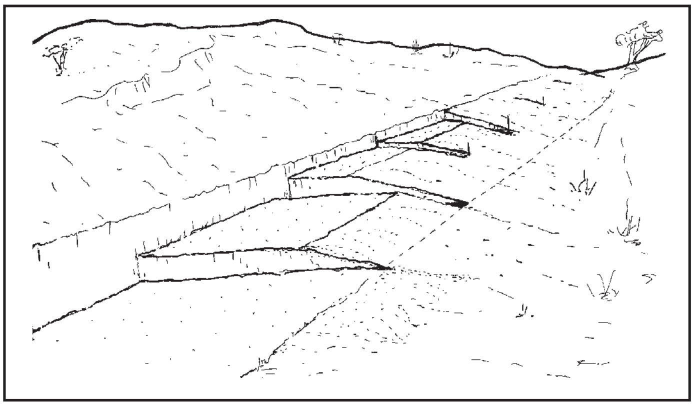


Figure 10 – E3.1: Sequence of excavating high cuts



Quality control

- Visual observations must be supported by measurements from level reference marks (survey stakes and slots) to ensure that excavation and filling are completed to design levels at each station. With the use of boning rods, the level terrace must be checked so that it is to the correct grade between the stations.
- The width of the level terrace must be checked by tape every 100m. The longitudinal levels must be checked every 20m using a levelling instrument or boning rods or profiles.
- As a guide the compaction can be checked by counting the number of passes made by roller and checking that no visible roller imprints are present on the finished product. These should comply to the specifications set in the standard. (refer to District Road Works Manual **Volume 2 Manual A2**).

Environment, health and safety

- Where any side-borrow has been made outside the formation width, it must be rehabilitated to discourage ponding of water and/or possible erosion.
- At any excavation face the use of heavy tools combined with the threat of falling material constitutes a risk situation and labourers must be well-spaced to avoid injury.
- In extremely dry areas, dust reduction measures (e.g. dampening the soil with water) must be considered if unhealthy levels of dust are suspected.
- If cut to spoil, the material dumped should be spread out and not left in heaps.
- Where there is a high cut face, it should be stepped to reduce land slides in high slopes.

EMBANKMENT (FILLING)

Definition

This method is employed where it is necessary to raise the road level usually across low-lying land with poor drainage, adjacent to bridges and culverts and on low sections of the road as dictated by the vertical alignment. (see **Section C1** of this manual)

Resources

Tools

- Picks
- Shovels
- Wheelbarrows
- Heavy duty rakes
- Watering cans
- String and line level (or camber board with spirit level)
- Straight edge 3m
- Tape measure 30m
- Ranging rods with profile boards

Labour

The labour required for this activity will vary depending on the workload. However, the limits to the numbers of labourers will be related to the capacity of the hauling and compaction equipment.

Equipment

- Pedestrian (or sit-on) roller
- Tractor and trailer (or tipper)
- Bowser (towed or self-propelled)

Productivity

TABLE 1 – E3.1: PRODUCTIVITY FOR MANUAL EXCAVATION

EXCAVATION	Average Productivity by soil condition in (insitu volume) m³/workerday				Remarks
	Soft	Medium	Hard/ Stony	Rock	
Recommended task rate	5 m³/wd	3.5 m³/wd	2.5 m³/wd	daywork (0.8 m³/wd)	Includes piling of the excavated material on the sides of the borrow pit or throwing to the centre of the road when ditching.

TABLE 2 – E3.1

LOADING UNLOADING SPREADING	Average Productivity in (loose volume) m³ per worker day			Remarks
	Loading	Unloading	Spreading	
Recommended task rate	6 ~ 9 m³/wd	12 ~ 16 m³/wd	6 ~ 9 m³/wd	Loading: varies according to lift/height. Unloading: varies if unloading only from the back or from three sides of the trailer. Judgement of supervisor is required.

TABLE 3 – E3.1

COMBINED UNLOADING AND SPREADING	Average Productivity in (loose volume) m³ per worker day		Remarks
	Loading	Unloading and Spreading	
Recommended task rate	6 ~ 9 m³/wd	4 ~ 6 m³/wd	Judgement of supervisor is required.

TABLE 4 – E3.1

WHEELBARROW HAULAGE RATES		Wheelbarrow Haulage Productivity by haulage distance per worker day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m³)	No. of Trips	Volume (m³)	No. of Trips	Volume (m³)	Estimated volume of wheelbarrow is 40 litres/trip excluding excavation
	0~20m	190	7.6	170	6.8	130	5.2	
	21~40m	170	6.8	150	6.0	120	4.8	
	41~60m	150	6.0	135	5.4	100	4.0	
	61~80m	130	5.2	115	4.6	90	3.6	
	81~100m	110	4.4	100	4.0	75	3.0	
	101~120m	90	3.6	80	3.2	60	2.4	
	121~150m	65	2.6	55	2.2	45	1.8	

TABLE 5 – E3.1

MANUALLY LOADED TRACTOR/TRAILER		Equipment Haulage Productivity by two trailers per tractor combination per day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	Estimated volume of tractor-towed trailer is 3 m^3/trip
	0.0~0.5km	37	111	34	102	30	90	
	0.6~1.0km	30	90	26	78	21	63	
	1.1~1.5km	25	75	21	63	16	48	
	1.6~2.0km	21	63	18	54	13	39	
	2.1~2.5km	18	54	15	45	11	33	
	2.6~3.0km	16	48	13	39	10	30	
	3.1~3.5km	15	45	12	36	8	24	
	3.6~4.0km	13	39	10	30	7	21	
	4.1~4.5km	12	36	10	30	7	21	
	4.6~5.0km	11	33	9	27	6	18	

TABLE 6 – E3.1

MANUALLY LOADED TRACTOR/TRAILER		Equipment Haulage Productivity by one trailer per tractor combination per day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	Estimeted volume of tractor-towed trailer is 3 m^3/trip
	0.0~0.5km	25	75	23	69	21	63	
	0.6~1.0km	21	63	19	57	16	48	
	1.1~1.5km	18	54	16	48	13	39	
	1.6~2.0km	16	48	14	42	11	33	
	2.1~2.5km	15	45	12	36	10	30	
	2.6~3.0km	13	39	11	33	8	24	
	3.1~3.5km	12	36	10	30	7	21	
	3.6~4.0km	11	33	9	27	7	21	
	4.1~4.5km	10	30	8	24	6	18	
	4.6~5.0km	10	30	8	24	6	18	

TABLE 7 – E3.1

MANUALLY LOADED TIPPER/TRUCK		Equipment Haulage Productivity by tipper/truck per day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	Estimeted volume of tipper/truck is 5 m^3/trip. The number of trips are applicable for all trucks with capacity of less than 10 m^3 but number of loaders will be increased.
	0 ~ 2 km	22	110	18	90	16	80	
	2 ~ 4 km	19	95	15	75	12	60	
	4 ~ 6 km	16	80	12	60	10	50	
	6 ~ 8 km	11	55	8	40	7	35	
	8 ~ 10 km	8	40	6	30	5	25	

TABLE 8 – E3.1

WATERING	Average Productivity Rates per day		Remarks
	Manual watering by labour	Using tractor-towed or motorized waterbowser	
Recommended output rates	4 ~ 6 m^3/wd	5 ~ 15 trips/bowsedays	Manual watering includes hauling water within source of 150 m. Bowser productivity depends on distance, road condition and demand of watering. Judgement of supervisor is required.

TABLE 9 – E3.1

COMPACTION	Average Productivity Rate per day			Remarks
	Manual compaction by hand rammers	Equipment compaction by pedistrain rollers	Equipment compaction by ride-on rollers	
Recommended output rates	9 m^2/wd (max. thickness <150mm)	700 m^2/rollerday (max. thickness <200mm)	1400 m^2/rollerday (max. thickness <200mm)	Manual compaction with hand rammer is effective for side slopes and back filling of structure works where rollers cannot be used.

Work method

The quarry and haulage operations are organized in a similar manner to those for gravelling (see **Section F** of this manual).

Initially, an estimate of the width of the cleared activitys must be made (as indicated in **Section E2** of this manual) to ensure that the cleared area is adequate to construct the embankment.

After completion of the clearing activities, the vertical alignment is fixed using ranging rods with adjustable profiles. However, instead of fixing the centreline profiles at 1m above the required level, they should be fixed at final level of the centreline. The alignment should be set out and checked using the methods described in **Section E1** of this manual.

It is necessary to set out the toe of the embankment and, as the fill rises, the toe of the shoulder. Pegs should be established for these points using the details in **Figure 11-E3.1**.

When the toe position T is determined, a peg should be installed. A batter profile of 1 : 1 should also be erected to guide the earthworks fill. Profile boards should also be erected to show the position and finished levels of the centreline.

FIGURE 11 – E3.1 EMBANKMENT SETTING OUT

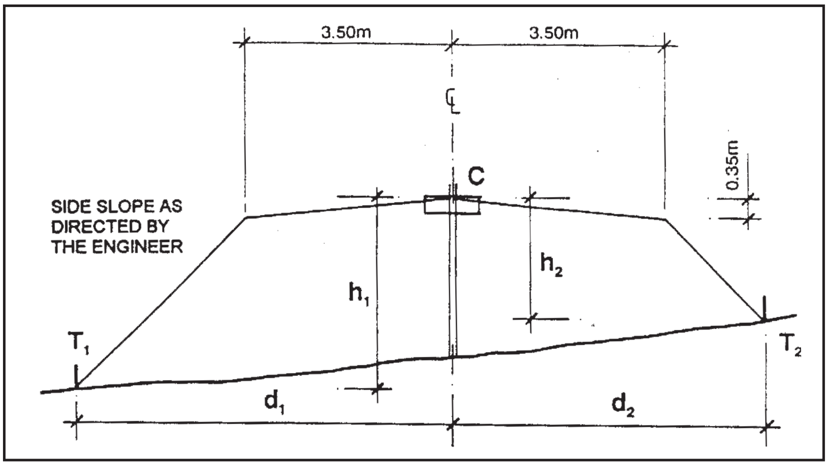
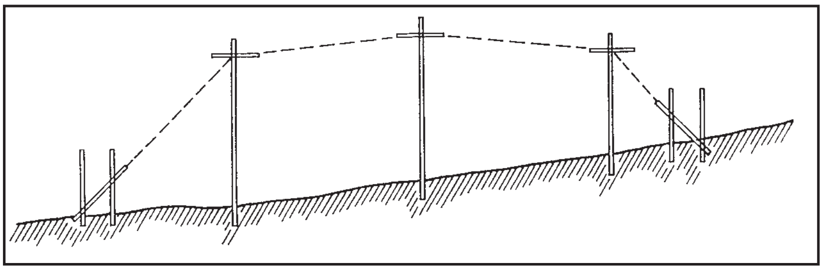


TABLE 10 – E3.1

h (m)	d (m) @ 1:1 Side Slope	d (m) @ 1:2 Side Slope	h (m)	d (m) @ 1:1 Side Slope	d (m) @ 1:2 Side Slope
0.50	3.65	3.80	2.10	5.25	7.00
0.60	3.75	4.00	2.20	5.35	7.20
0.70	3.85	4.20	2.30	5.45	7.40
0.80	3.95	4.40	2.40	5.55	7.60
0.90	4.05	4.60	2.50	5.65	7.80
1.00	4.15	4.80	2.60	5.75	8.00
1.10	4.25	5.00	2.70	5.85	8.20
1.20	4.35	5.20	2.80	5.95	8.40
1.30	4.45	5.40	2.90	6.05	8.60
1.40	4.55	5.60	3.00	6.15	8.80
1.50	4.65	5.80	3.10	6.25	9.00
1.60	4.75	6.00	3.20	6.35	9.20
1.70	4.85	6.20	3.30	6.45	9.40
1.80	4.95	6.40	3.40	6.55	9.60
1.90	5.05	6.60	3.50	6.65	9.80
2.00	5.15	6.80			

FIGURE 12 – E3.1: SETTING OUT PROFILES FOR EMBANKMENT WORKS



To ensure proper compaction of the fill, the roller must be working in the same area as where the people are working. The fill layers must be compacted by roller (self-propelled or towed) and the loose fill layers must not exceed 150mm loose. The fill layers must be watered (where necessary) such that the moisture content at compaction is between 80% and 105% of the optimum moisture content (See **Section C1.5**). As a guide a minimum of six passes of compaction shall be applied or until no roller imprint on the surface can be recognized. The compaction should be done according to set specifications (see District Road Manual **Volume 2 Manual C2**). The uniformity of compaction of a fill layer is very critical on an embankment in order to avoid unnecessary differential settlement. It is, therefore, of utmost importance that compaction is carefully monitored throughout the construction of the embankment.

Quality Control

- The dimensions (width and height) of the embankment must be checked for accuracy every 20m. The levels should be strictly controlled by continuous boning for each fill layer in order to ensure the correct height.
- The smoothness of the longitudinal profile must be checked every 20m. This can be done by using a 3m straight edge.
- The compaction can be checked by counting the number of passes made by roller and checking that no visible roller imprints are present on the finished product.
- A proper test should be done to comply with the standard specifications.

Environment, health and safety

- Where any side-borrow has been made outside the formation width, it must be rehabilitated to discourage ponding of water and/or possible erosion.
- At any excavation face the use of heavy tools combined with the threat of falling material constitutes a risk situation and labourers must be well-spaced to avoid injury.
- In extremely dry areas, dust reduction measures (e.g. dampening the soil with water) must be considered if unhealthy levels of dust are suspected.
- A first aid kit must be readily available on site for any emergency.

RESHAPING

Definition

This method is employed where the existing road does have an existing formation and camber of consolidated high quality material that can serve well on the improved road. The improvement activities for reshaping focus on strengthening of the camber and restoration of a complete drainage system.

Resources

Tools

- Pick or mattock or hoe
- Shovel
- Strings and pegs
- Boning rods or ranging rods with profile boards
- Camber board and spirit level

Labour

The gang sizes will vary according to the intensity of the workload. The workload is directly proportional to the amount of material that must be brought into the formation of the camber.

Equipment

- Vibrating pedestrian roller
- Water bowser (where necessary, it can either be self propelled or tractor-towed)

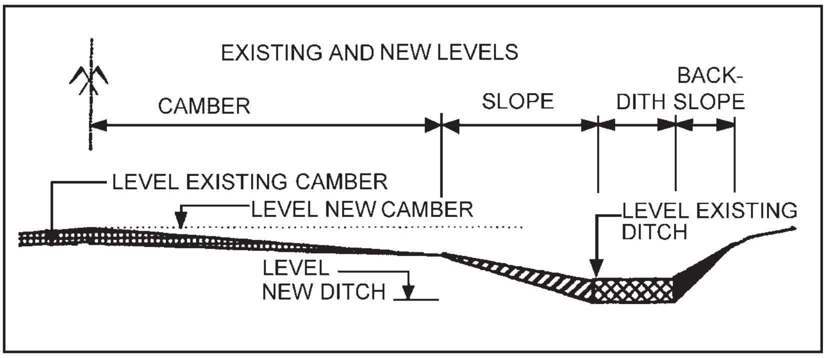
Productivity

The highly variable workload throughout any road section on reshaping activities makes it quite difficult to predict the work outputs. Where the quantities have been estimated before the work starts, the task rates applicable to excavation and spreading can be applied.

Work method

The centreline of the road is determined taking into consideration the existing camber. Pegs are fixed along the centreline at 10m intervals and the entire cross section is set out at each point (i.e. pegs to demarcate the shoulder break point, the drain invert limits and the outer edge of the backslope).

FIGURE 13 – E3.1 RESHAPING



The levels of the shoulder break point are carefully selected at each point such that excavations shall only be carried out in the side drains and the material used to build up camber in the roadway. The levels are then fixed onto the shoulder break point and translated to the centreline. Ranging rods with profile boards fixed at 1m above centreline level shall be fixed along the centreline. It is also advisable to paint the levels onto the pegs along the centreline and the **shoulder break points**.

At each 10m interval, 1m wide slots are then constructed so as to guide the rest of the reshaping exercise. Each slot is constructed by excavating suitable material from the side drains and using it this material to form the camber within the slot.

If the material excavated from the ditches is not sufficient to build up the camber to the required level, then extra material shall be obtained by widening and/or deepening the drains. If material is still not sufficient, then borrowing from approved quarries may e considered.

Watering shall be done to bring the material to the appropriate moisture content for compaction. The compaction must be done in layers not exceeding 15cm loose.

Quality Control

- The cross section must be checked by tape every 100m. The width of the roadway and the side drain dimensions must conform ton the specified dimensions.
- The camber must be checked by use of camber board and spirit level to ensure the design crossfall of 8% or as designed by the Engineer.
- The mitre drain numbers, location and dimensions must also be checked for conformity.
- The smoothness of the longitudinal profile must be checked every 20m. This can be done by using a 3m straight edge.
- The compaction can be checked by counting the number of passes made by roller and checking that no visible roller imprints are present on the finished product.

Environment, health and safety

- Where any side-borrow has been made outside the formation width, it must be rehabilitated to discourage ponding of water and/or possible erosion.
- At any excavation face the use of heavy tools combined with the threat of falling material constitutes a risk situation and labourers must be well-spaced to avoid injury.
- In extremely dry areas, dust reduction measures (e.g. dampening the soil with water) must be considered if unhealthy levels of dust are suspected.
- A first aid kit must be readily available on site for any emergency.

E3.2 SIDE DRAINS AND CAMBER FORMATION

The operation of side drains and camber formation consist of excavating the side drains, throwing the material into the roadway and shaping it to form camber and compact it to form the subgrade of the road.

The activities involved in this operation include ditching, sloping, back sloping, camber formation including compaction.

DITCHING AND SPREADING

Definition

This activity involves the excavation of the ditch (leaving the walls vertical), and throwing suitable excavated material onto or near the roadway centreline. The material thrown into the roadway area is then spread, watered (if necessary) and compacted. This forms the first part of constructing the camber.

Resources

Tools

- Pick, mattock or hoe
- Spades
- Heavy duty rake for spreading
- Shovels
- Watering cans

Labour

The gang sizes will be determined by the volumes of excavations involved on.

Equipment

- Vibrating roller
- Water bowser (where necessary, it can either be self propelled or tractor-towed)

Productivity

For spreading, the productivity is usually 6m^3 to 9m^3 per worker day.

TABLE 1 – E3.2

DITCHING	Average Productivity by hardness of soil in (insitu volume) m^3 per worker day			Remarks
	Soft	Medium	Hard	
Recommended task rate	3.5 m^3/wd	3.0 m^3/wd	2.5 m^3/wd	Judgement of supervisor is required.

TABLE 2 – E3.2

SPREADING	Average Productivity rate per workerday	Remarks
Recommended task rate	6 ~ 9 m^3/wd	

Table 3 – E3.2

WATERING	Average Productivity Rates per day		Remarks
	Manual watering by labour	Using tractor-towed or motorized waterbowser	
Recommended output rates	4 ~ 6 m^3/wd	5 ~ 15 trips/bowsedays	Manual watering includes hauling water within source of 150 m. Bowser productivity depends on distance, road condition and demand of watering. Judgement of supervisor is required.

Table 4 – E3.2

COMPACTION	Average Productivity Rate per day			Remarks
	Manual compaction by hand rammers	Equipment compaction by pedistrain rollers	Equipment compaction by ride-on rollers	
Recommended output rates	9 m^2/wd (max. thickness <150mm)	700 m^2/rollerday (max. thickness <200mm)	1400 m^2/rollerday (max. thickness <200mm)	Manual compaction with hand rammer is effective for side slopes and back filling of structure works where rollers cannot be used.

Work method

Two situations exist for ditching:

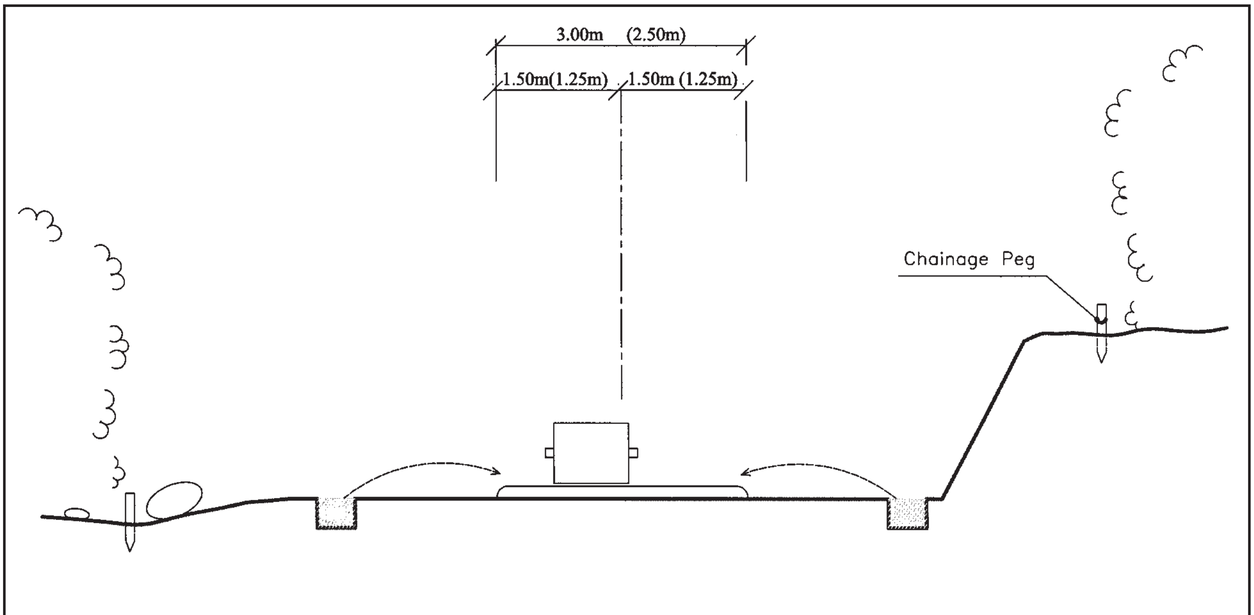
- Ditching after excavation to level
- Ditching where excavation to level has not taken place

Ditching after excavation to level

Four strings must be fixed along the level road bed terrace. One string on each side of the centreline will demarcate the width of the ditches. Another string shall be placed at the centre of the roadway to define the exact area where the material excavated from the ditch shall be thrown. The strings shall be fixed in place by a number of pegs.

Excavation of the ditches may then commence. Each worker must be given sticks which has been cut to the required depth and width of the drain for guidance on how much to excavate. Supervision on this activity is of paramount importance as the drain must be excavated to the correct width and depth at all points.

FIGURE 1 – E3.2: DITCHING



Ditching where excavation to level has not taken place

Although in such cases the land is generally flat, it is not exactly flat and horizontal. This means the depths of excavation for the ditches will vary from point to point. Ditch slots must be dug first (at 10m intervals) to guide the excavation of the rest of the ditch to the correct levels.

Four strings must be fixed along the road. One string on each side of the centreline will demarcate the width of the ditches. Another string shall be placed at the centre of the roadway to define the exact area where the material excavated from the ditch shall be thrown. The strings shall be fixed in place by a number of pegs.

The slots are then excavated at each 10m peg. The ditch slot is excavated to the correct width and depth of the drain but for a length of 1m along the road. The material from the slot is thrown in the middle of the road as demarcated by the strings.

Once the slots have been correctly excavated, the rest of the ditch can be excavated by joining up the slots. The level control of the bottom of the ditch is done by fixing ranging rods with profile boards 1m above the bottom of alternate slots on the same side of the road (this is done on a straight grade). Alternatively, the level control can be done by fixing strings on the levels marked on shoulder break point pegs. The string is tied so tightly that there is no slack. The bottom of the ditch will be at a fixed distance below such a string.

In both cases (with or without excavation to level), a separate group of workers should simultaneously be engaged in spreading all the material that has been excavated from the ditch. The spread material should then be watered (if necessary) and compacted in layers not exceeding 15cm loose. This compaction is referred to as the second compaction.

Good use of the natural moisture content can be made by compacting excavated material as soon as possible after excavations. This will help to reduce the amount of water to be brought in by water bowser.

Quality control

- Ensure that the ditch dimensions (width and depth) are as per the design.
- The ditch invert gradient must be checked for compliance at all points. It is very important that the ditch invert slopes are accurately constructed as errors may lead to water flowing in the wrong direction.
- The compaction can be checked by counting the number of passes made by roller and checking that no visible roller imprints are present on the finished product.

Environment, health and safety

- A first aid kit must be readily available on site.
- In extremely dry areas, dust reduction measures (e.g. dampening the soil with water) must be considered if unhealthy levels of dust are suspected.

SLOPING AND CAMBER FORMATION

Definition

The sloping operation involves two activities, namely, sloping (fore sloping) and back sloping. This involves excavating the drain slope and backslope and throwing the excavated material into the roadway. The material is then used to form the camber as a different activity. The camber formation activity involves the spreading of the material excavated from the side drain and compacting it to the required cross fall.

Resources

Tools

- Pick, mattock or hoe
- Spades
- Heavy duty rake for spreading
- Shovels
- Watering cans
- Camber board
- Spirit level

Labour

The gang sizes will be determined by the volumes of excavation and spreading involved on the activity.

Equipment

- Vibrating roller
- Water bowser (where necessary, it can either be self propelled or tractor-towed)

Productivity

Table 5 – E3.2

SLOPING AND BACKSLOPING	Average Productivity by hardness of soil in (insitu volume) m^3 per workerday			Remarks
	Soft	Medium	Hard	
Recommended task rate	4.0 m^3/wd	3.5 m^3/wd	3.0 m^3/wd	Judgement of supervisor is required.

Table 6 – E3.2

CAMBER FORMATION	Average Productivity in m^2 per worker day		Remarks
	in ordinary soil	in graveling activity	
Recommended task rate	180 m^2/wd	140 m^2/wd	

Table 7 – E3.2

WATERING	Average Productivity Rates per day		Remarks
	Manual watering by labour	Using tractor-towed or motorized waterbowser	
Recommended output rates	4 ~ 6 m^3/wd	5 ~ 15 trips/bowsedays	Manual watering includes hauling water within source of 150 m. Bowser productivity depends on distance, road condition and demand of watering. Judgement of supervisor is required.

Table 8 – E3.2

COMPACTION	Average Productivity Rate per day			Remarks
	Manual compaction by hand rammers	Equipment compaction by pedistrain rollers	Equipment compaction by ride-on rollers	
Recommended output rates	9 m^2/wd (max. thickness <150mm)	700 m^2/rollerday (max. thickness <200mm)	1400 m^2/rollerday (max. thickness <200mm)	Manual compaction with hand rammer is effective for side slopes and back filling of structure works where rollers cannot be used.

Work method

Sloping is done first before back sloping. Before sloping is done, fix one string line on each side of the road showing the edges of the shoulder break point. The strings will enable the workers to excavate the slope evenly so that the roadway edge is smooth and well defined. The excavated material must be thrown to the centre of the road to build up the camber.

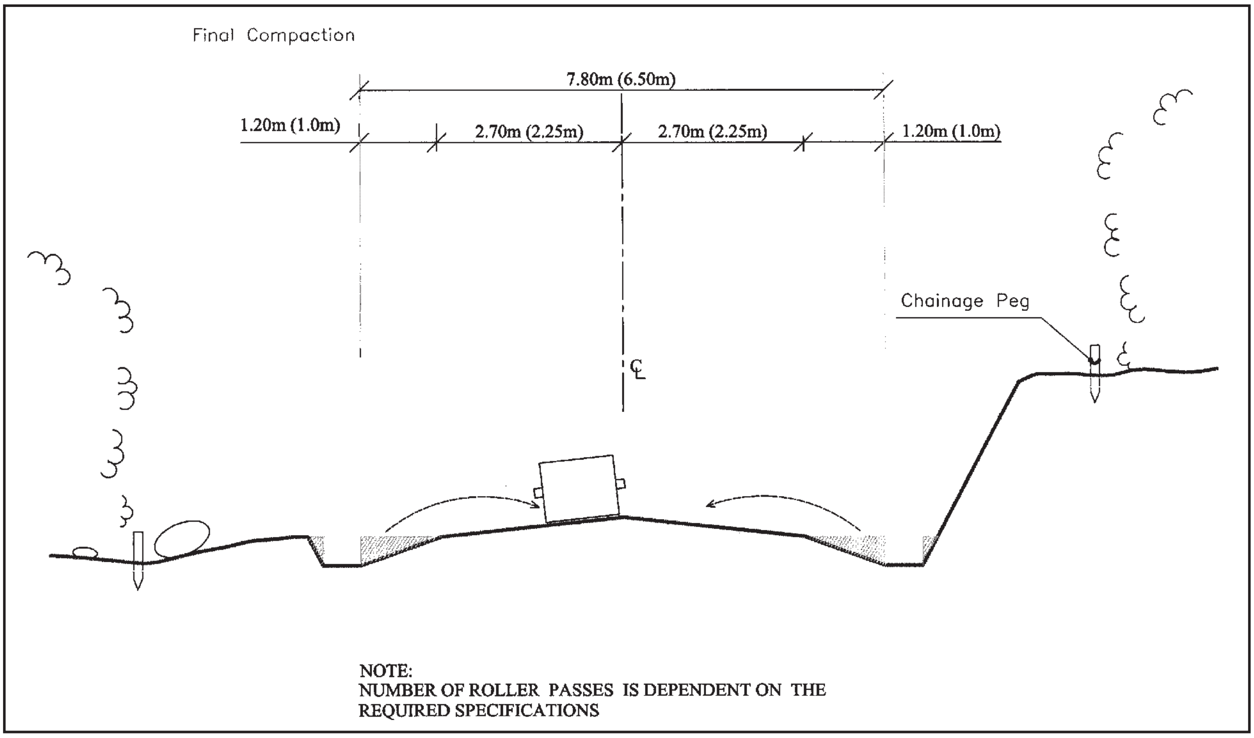
Back sloping follows after the sloping. It must be noted here that most of the cross sections are designed such that, under normal conditions (where there are two side drains and no super elevation, etc.), only some material from the backslope will be used.

The material from the backslope (where required) may need to be thrown onto or near the road centreline to build up the final camber to the required levels. All material that is to be disposed of (wasted) must be transferred by throwing or, if the distance to the deposit area is too far, by wheelbarrow to the lower side of the road.

It is vital that the drain is completely cleared of any backslope debris before the task can be declared finished.

Before camber formation work begins, replace the two string lines showing the shoulder break points. Also, place a string along the roadway centreline. The camber is formed by spreading the material excavated from the drains. The material is spread evenly from the centreline 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. Use a 3m straight edge to check the longitudinal smoothness of the compacted camber.

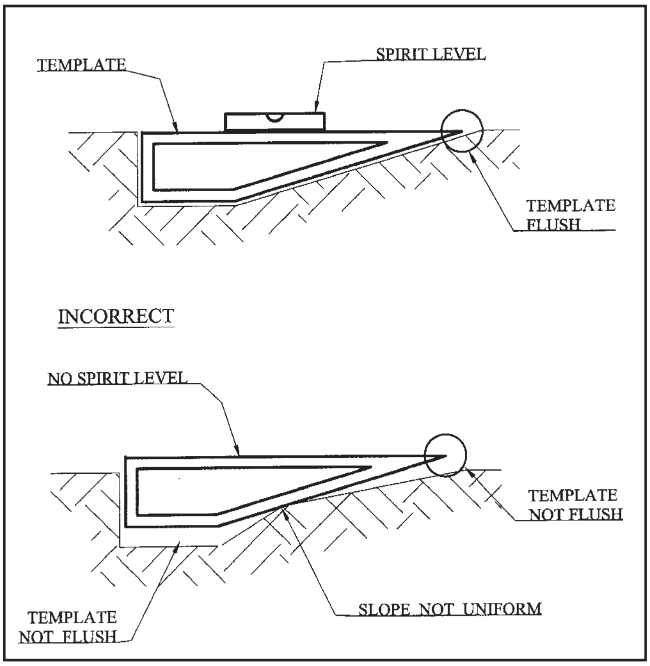
FIGURE 2 – E3.2: SLOPING



Quality control

- The slope must be checked for correctness using a slope template and a spirit level.
- The camber must be checked for correctness at least every 20m along the road.
- The width of the formation needs to be checked every 100m along the road.
- The waste material from the backslope must be evenly spread at the disposal area so as not to encourage erosion.
- The compaction can be checked by counting the number of passes made by roller and checking that no visible roller imprints are present on the finished product.

FIGURE 3 – E3.2: CHECKING THE SLOPE FOR CORRECTNESS



Environment, health and safety

- The waste material from the backslope must be evenly spread at the disposal area so as not to encourage erosion.
- A first aid kit must be readily available on site.

Section E4

Structures

Section E4
Structures

STRUCTURES

Road drainage structures and associated works, such as erosion protection form a considerable part of road works in terms of both the purpose they serve and the cost. The details of design and construction of structures can be found in **Section B** of this Manual, District Road Works - Standard Design Manuals **Volume 4 Manual B** and **B2**. This section provides brief information on erosion protection in the drains using Scour Checks and Subsurface drains that may not be detailed in the parts stated above.

E4.1 SCOUR CHECKS

Where longitudinal drain gradients exceed 4%, scour checks will be provided to reduce the speed of running water in order to reduce erosion. Scour checks are built using concrete, stones and sticks, as instructed by the Engineer. The conditions that determine the need for scour checks and their intervals has already been discussed in **Section B** of this Manual. The Engineer will determine or approve any requirement or specifications for scour checks.

Resources

Tools

- Template
- Spirit level
- Sledge Hammer
- Mason Hammer
- Cutlass
- Shovel

Materials

- Stones
- Sticks

Productivity

SCOUR CHECK CONSTRUCTION	Average Productivity Rate per worker day			Remarks
	Construct scour check	Stone collection	Stick collection	
Recommended task rates	4 ~ 8 Nos./wd	2 ~ 3 m^3/wd	80 ~ 100 Nos./wd	Task rate for construction of scour checks excludes collection of stones/sticks

Work Method

Only construction using stones or sticks commonly used for district or rural roads will be briefly outlined in this section.

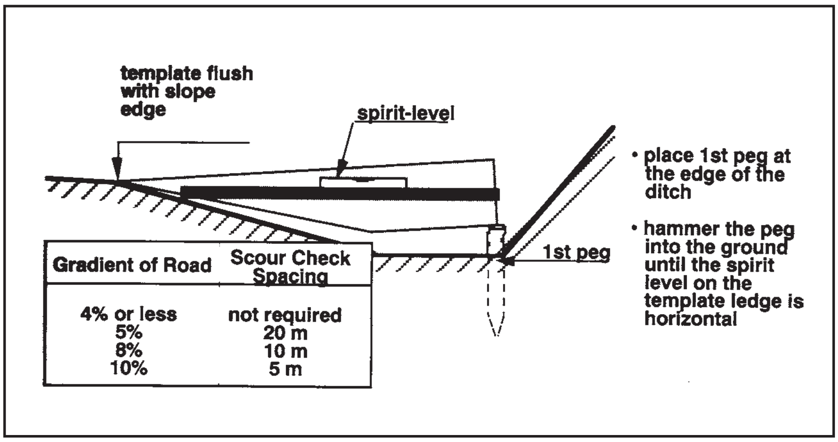
The setting out of all scour checks involves the use of basic setting out techniques of gradients, level transfer or offsets described in **Section E** of this Manual. The level of most common scour checks that the reader will encounter will be set at a minimum of 0.2m below the carriageway edge.

Use of Stones

The following basic steps are involved:

1. Collect natural stones of adequate size and weight (minimum 20kg), and haul to site.
2. Excavate foundation trench and apron bottom as shown in drawing Number: WWP001 of District Road Works Manual **Volume 4 Manual B**.
3. Place stones, backfill and compact with hand rammer or sledgehammer.
4. A scour check template may be used for correct shaping of the scour checks as shown in **Figure 1-E4.1** of this Manual.
5. Apron of stone or grass should be constructed below the scour checks to a length of 40cm. The stone footing must be dug in. In case of grass appron, anchored by driving pegs through to the ground.

FIGURE 1 - E4.1: INSTALLATION OF SCOUR CHECKS



Using Sticks

The procedure for construction of scour using sticks is similar to the procedure for stones above and is further detailed in **Section G5** of this Manual. The reader should note that the appropriate stick or wood materials should have a minimum diameter of 5cm and minimum length of 40cm. Also see drawing **Number: WWP001** of District Road Works Manual **Volume 4 Manual B**.

Quality Control

Test	Method	Frequency	Tolerance
Spacing of scour checks	Tape	all	+ / - 20cm
Shape	Template	all	-

E4.2 SUB-SURFACE DRAINAGE

The ground water table normally follows the general land profile. The water table may sometimes rise nearer or to the ground surface following high rains. Further, when there is the occurrence of impermeable layers close to the surface in the ground, temporary water table may occur during rains.

In both the circumstances cited above, the ground or soil conditions may become unsuitable for construction of road. When such conditions are encountered, appropriate technical and economic measures must to be taken. Two certain measures to be taken without having to realign the road include:

1. Raising the road by means of constructing an embankment to desired elevation above the ground level (see **Sections C1** and **E3.1** of this Manual)
2. Drainage of the ground to lower or dispose of the water.

When embankments are constructed, they may also impede disposal of floodwater or other surface water. It will be required to provide drainage lines underneath the embankment. Normally the ground or soils can be drained using the second option by providing channels of different types, open or subsurface channels as follows:

1. Culverts or other open channels are used in the case of high runoff water. This has already been described in **Section B** of this Manual and District Road Works Manual **Volume 4 Manual B**.
2. The method of increasing seepage through a designed granular material (ranging from sandy soil – bigger size aggregates or stones) under the embankment or roadbed is applied to discharge the water or to dispose of water from adjacent saturated soil. The **Figures 1-E4.2** and **3-E4.2** show typical subsurface drainage systems. Such drains may also be called French drains. The granular soils or stones encourages horizontal or lateral drainage of water as opposed to a cappillary rise.

FIGURE 1 – E4.2: SUB SURFACE FRENCH DRAIN - FRENCH DRAIN

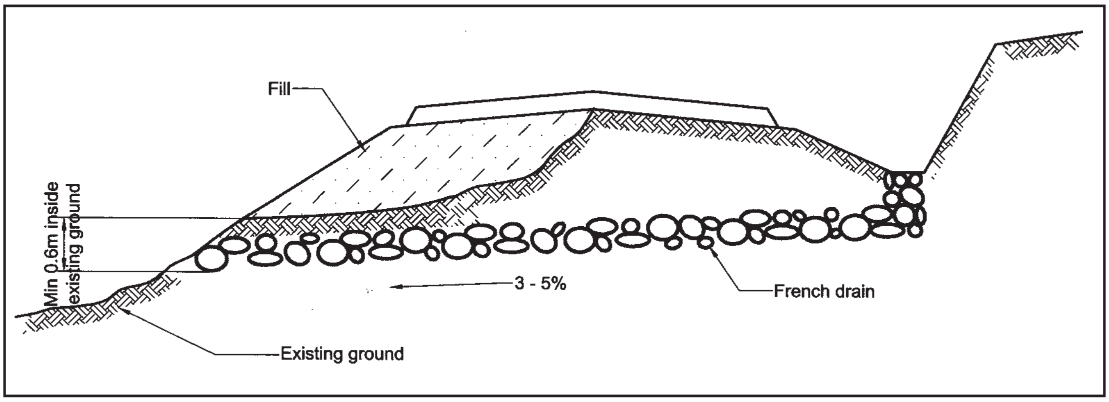


FIGURE 2 – E4.2: SECTION THROUGH A FRENCH DRAIN

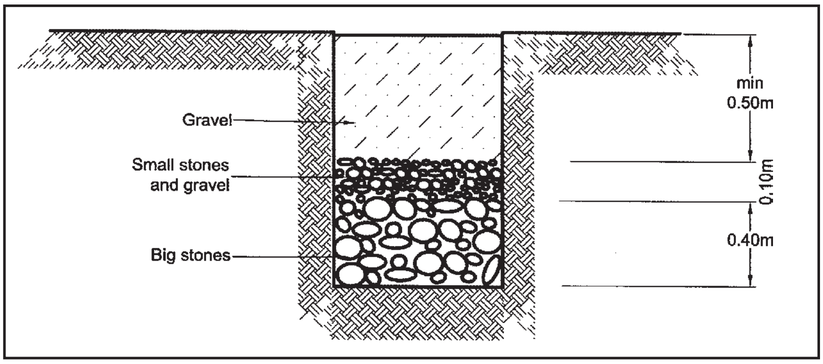


FIGURE 3 – E4.2: SUB SURFACE DRAIN UNDER EMBARKMENT

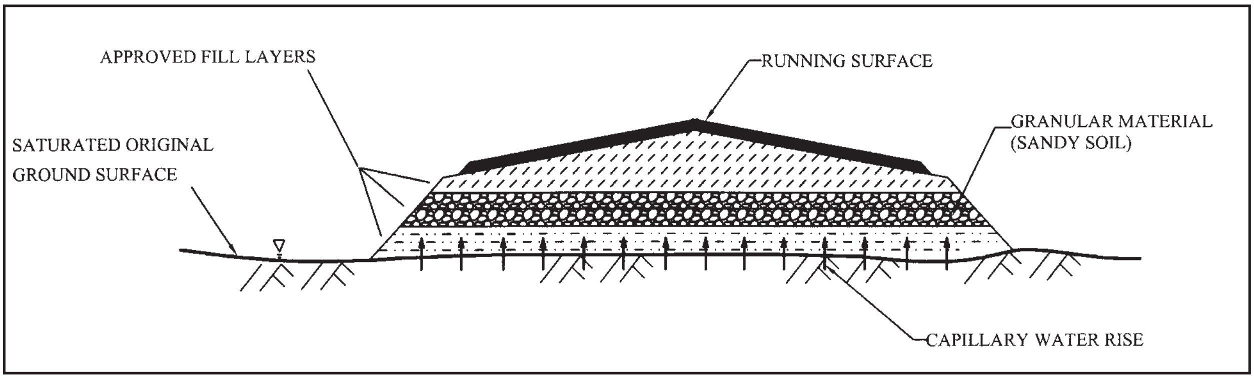
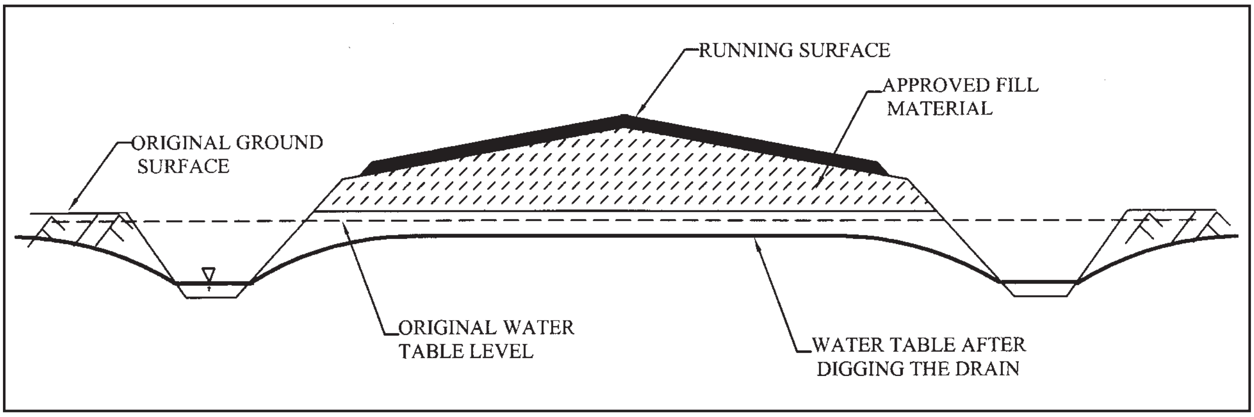


FIGURE 4 – E4.2: SUB SURFACE DRAIN UNDER EMBARKMENT



The use of geo-textile material may be considered in situations where the road bed or embarkment is susceptible to upward movement of moisure from the subsurface structure or granular or saturated material.

The application of sub-surface drains by use of granular material under embankments can be improved further by providing a deepened side drain to remove the water off the embankment base and maintain lowered water levels. (see **Figure 3-E4.2** and **Figure 4-E4.2**)

Section F

Road Surfacing

Section F
Road Surfacing

ROAD SURFACING

F1 DEFINITION AND TYPES OF ROAD SURFACING

DEFINITION

The Road Surface is the top most layer of the pavement. It consists of the wearing course and sometimes a base course or binder course.

The road surface plays the functions of:

- Bearing the direct traffic loads by spreading the load so that the subgrade or the layer beneath is not overstressed.
- Together with the camber, to prevent water from entering into and weakening the lower load bearing layers.
- Resist skidding of vehicles and traffic abbrasion.

TYPES OF ROAD SURFACING

There are various options for surfacing earth roads and these include the following:

- Gravelling
- Stone Packing
- Surface dressing or slurry sealing
- Block paving
- Stone dressing
- Concrete strips

The choice of the type of surface materials above depends on various factors which mainly influence the cost and sustainability. These may include availability, location of road (e.g. dust effecting the rural or urban areas), maintenance requirements, terrain (e.g. the need to use erosion resistant option in hilly sides) and availability of skilled persons.

Gravelling is the most widely used option for district or community roads in Uganda. **Section F2** of the Manual will therefore place emphasis on gravelling operations, while alternative surfacing options are dealt with in **Section F3**.

Stone Packing

This involves hand packing of stones of a specified grading or size. It may often be cost effective alternative in the long run.

Surface dressing or slurry sealing

Also known as seal-coat or surface treatment and essentially consists of applying a film of binder followed by a layer of stone chippings, after which the surface is rolled before opening to traffic.

Block paving

Where concrete blocks can be manufactured (by machine or manually) in the locality of the road, then concrete block paving can be a cost effective solution in the long term. The concrete blocks may be reused at the end of the pavement life cycle.

Stone dressing

Stone dressing involves use of rough surface stones held together with concrete binders into a pavement. It can also provide a cost effective option in long term, being a durable structure and requiring low maintenance. It is mainly used in urban areas and village roads.

Gravelling

Gravelling involves placing a layer of gravel (selected granular, mainly laterite) material directly on the subgrade 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.

In most cases, the gravel layer is placed immediately after the completion of earthworks. In some cases, newly constructed roads are left un-gravelled for a period of time, allowing the base to settle and traffic to provide compaction. Gravelling 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.

Transport of gravel can be organised in many ways, depending on the distance from the gravel quarry to the site and the type of equipment available. The table on the right is a guide for selecting the type of transport appropriate for different haulage distances.

Tractor towing tipping trailers can be a very economical mode of transport when the hauling distance does not exceed 8 km. The trailers are more suitable than lorries in cases where manual loading is to be used. Several trailers can be used for one tractor so that one is loaded while the other transports materials to the site.

TABLE 1 - F1: APPROPRATE MEANS OF TRANSPORT FOR HAULING

Transport	Economical Distance
Wheelbarrow	10 ~ 150m
Animal carts	150 ~ 1000m
Tractor and Trailers	up to 5000m
Trucks	over 5000m

The thickness of gravel layers depends on the strength of the subgrade material, quality of available materials and the expected traffic loads. The appropriate gravel width and thickness is therefore provided depending on the class of district roads or by design of the Engineer.

The preparation operations normally carried out in advance of the gravelling and consist of:

- reshaping the road
- preparing quarry access roads
- preparing quarries
- initial excavation of gravel (stage 1)

The sequence of the actual gravelling works is as follows:

- main excavation of gravel in the quarry (stage 2)
- loading
- hauling
- off loading and spreading
- compaction
- stockpiling of gravel for maintenance

Gravelling is an expensive operation. Care should be taken to ensure the correct choice of method and each step of the gravelling process is carried out correctly to achieve a good quality road formation and running surface, with minimum erosion and maintenance problems under traffic use.

F2 GRAVELLING

F2.1 GRAVEL PROSPECTION

GRAVEL SOURCE

When selecting appropriate gravel quarries, a number of aspects need to be considered and these include:

- The quality of the gravel material
- The terrain / level where the quarry is located
- The depth of overburden over the gravel
- The quantity of good quality gravel available
- How to excavate the gravel
- How long access road needs to be constructed to access the quarry
- Hauling distance from the quarry to the road site
- Land ownership at the quarry site.

It is important to establish whether or not the quarry is located in low lying terrain. If so, this may well cause the quarry to become flooded and unworkable when it rains. Preferably, the gravel pit should be located close to your road to limit hauling distances.

The quality of the gravel needs to be determined well in advance of the project commencing gravelling works. This enables the project to prepare and negotiate gravel rates adequately in advance and to time the gravelling works to the optimal period of the year (dry season).

Although the process is called "gravelling" various materials can be used such as laterite, limestone and gravel. Most suitable materials consist of a mixture of stones, sand and clay. The stone particles will lock together and form a strong skeleton which spreads the traffic load to the natural soil. The sand and clay will act as a binder keeping the stone particles in place.

Much care needs to be taken in selecting your material. Suitable surface layers can be made of materials ranging from laterite and coral to very hard crushed stone. Some materials such as a coral and limestone have the tendency to harden when they are exposed to air, water and traffic compaction, while other types of rock may decompose, under the combined action of weather and traffic to form clay.

Information about soil characteristics is useful both to help in selecting sites, routes and to facilitate design and specification on the project. Usually, the Engineer will send samples to a soils laboratory. It must be recognised, however, that in many places good laboratory facilities are scarce and tend to be monopolised by favoured projects. In addition, laboratory tests can be expensive and time consuming in the types of dispersed projects most suited to labour-based methods.

Engineers and technicians are often limited to making some of the field tests described in **Section C1**. When used with laboratory tests taken on similar samples for other projects and with a sound knowledge built up by observing how similar materials have performed, these field tests can provide sufficient information for making sensible engineering decisions.

F2.2 PREPARATION OF QUARRY SITE AND ACCESS

Definition

Preparation of quarry site consists of removing of all vegetation, stumps, boulders, fences, structures, top soil (between original surface and the gravel material) and any other material considered unsuitable or inconvenient (in the working space) from the areas or those adjacent to gravel excavation site. Where necessary it will also consist of providing an improved access for haulage equipment.

Resources

Tools

- Hoes
- Mattocks
- Shovels
- Bush knives
- Pick-axes
- Rakes
- Wheelbarrows

Labour

The gang size depends on the size of quarry area, access length (if required), nature and difficulty of the preparation works and productivity targets. Sufficient work force is required to achieve the work in plan.

Materials

- Wooden pegs
- Strings/ropes of sisal twine

Productivity

The proposed tasks for preparation activities is as below:

TABLE 1 - F2.2

Activity	Task Rate	
Preparation of access road	50 ~ 60 m/work-day	
Clearing bush	200 ~ 1000 m^2/work-day	
Excavating overburden and loading onto wheelbarrow	2 ~ 4 m^3/work-day	
Hauling overburden with wheelbarrow (see note below)	**Quantity**	**No. of trips/day**
0 ~ 40m	10.5 m^3/work-day	210
40 ~ 60m	8.0 m^3/work-day	160
60 ~ 80m	6.5 m^3/work-day	130
80 ~ 100m	5.5 m^3/work-day	110

Note:

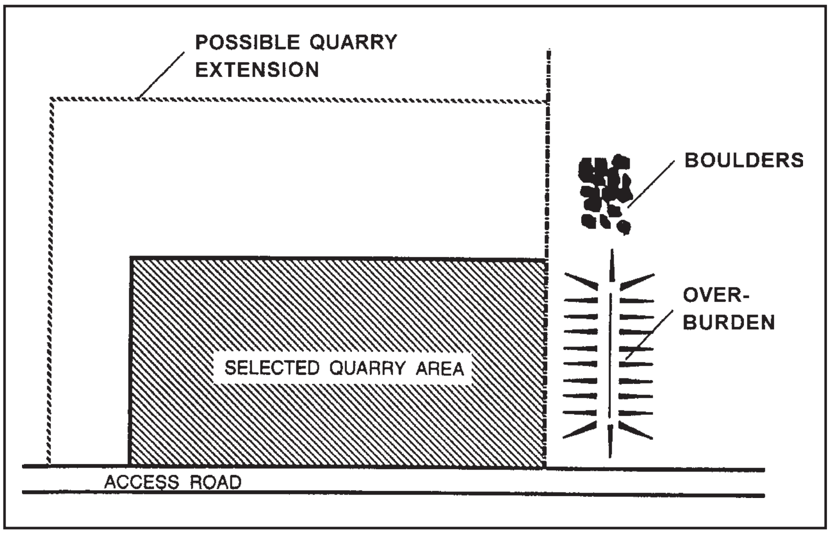
- Tasks are for tipping and hauling only excludes loading and spreading.
- These assume wheelbarrow capacity of 0.05 m^3 of insitu material when stuck level with the top of the bucket.
- use two wheelbarrows per hauling labourer
- A good haul route (make sure tasks are reduced to suit poor haul route)

Work Method

The area to be cleared is set by using tape measures, pegs and strings so that the quarry can be exploited as planned.

Cut all vegetation (including grass, bush, trees) and remove (stumps, boulders, fences and structures) that is in the quarry area using bushknives, mattocks and pickaxes. Haul and deposit all cut or removed materials to approved locations. Deposited material can be burnt only when approved by the Engineer.

FIGURE 1 - F2.2: PLANNING OVERBURDEN AND POSSIBLE EXTENSION



Excavate using hoes or mattocks the overburden, load onto wheelbarrows, haul and stock within 10m from the planned quarry area so that it can be reused to reinstate quarry or as directed by the engineer.

Improve the quarry access and make any provisions necessary for the maintenance through out the gravelling period.

Quality Control

Quality control for this work includes checking the dimensions of the area required for clearance and unwanted material in the quarry (prior to any excavations).

Environment Health and Safety

See (*reference to earlier clearing operation for bush and overburden removals*).

QUARRY PLANS AND ORGANISATION

Location

Where possible, gravel quarries should be located in the road reserve and adjacent to the road. This avoids the need for access roads and additional turning areas.

Where quarry sites are located away from the road, access will be needed and/or improved for haulage equipment to use.

Quarry Layout

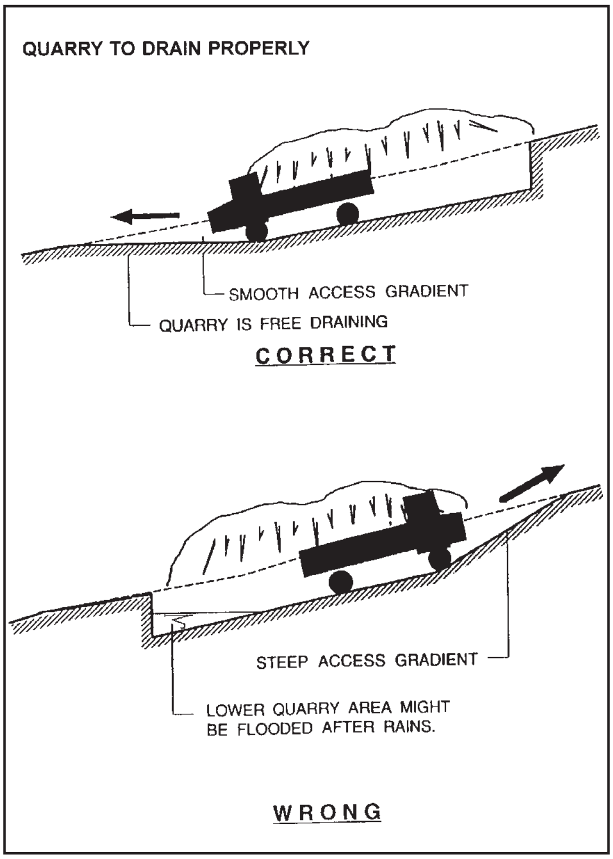
The quarry site and its layout must be well planned before any work starts. The quarry site must be planned so that:

- The quarry can be fully exploited with extraction of optimum amount of gravel
- The overburden is stockpiled in such a manner as to allow for future extension and ease in reuse to reinstate the quarry site (see **Figure 1-F2.2**)
- The best quality gravel is taken in case of variable quality in the site
- Environment damage by erosion or poor drainage is minimized (see **Figure 2-F2.2**)

The quarry lay out should allow for the following:

- Efficient excavations, stockpiling, loading, ample turning or maneuver space for the hauling equipment
- Haulage trucks or tractors and trailer to enter and leave without being in each other's way. A circular traffic flow, requiring only single lanes is ideal. If only a single access road is possible, then a double lane for traffic in both directions is required (see **Figure 3-F2.2**)

FIGURE 2 - F2.2: DRAINAGE OF QUARRY AT HILLSIDE



The quarry access must be continually maintained in order to ensure passage of haulage equipment throughout the gravelling period.

The follow **Figures 3** and **4** show how quarry sites and works should be organized for efficient gravelling operations.

FIGURE 3 - F2.2: TYPICAL QUARRY ACCESS PLAN

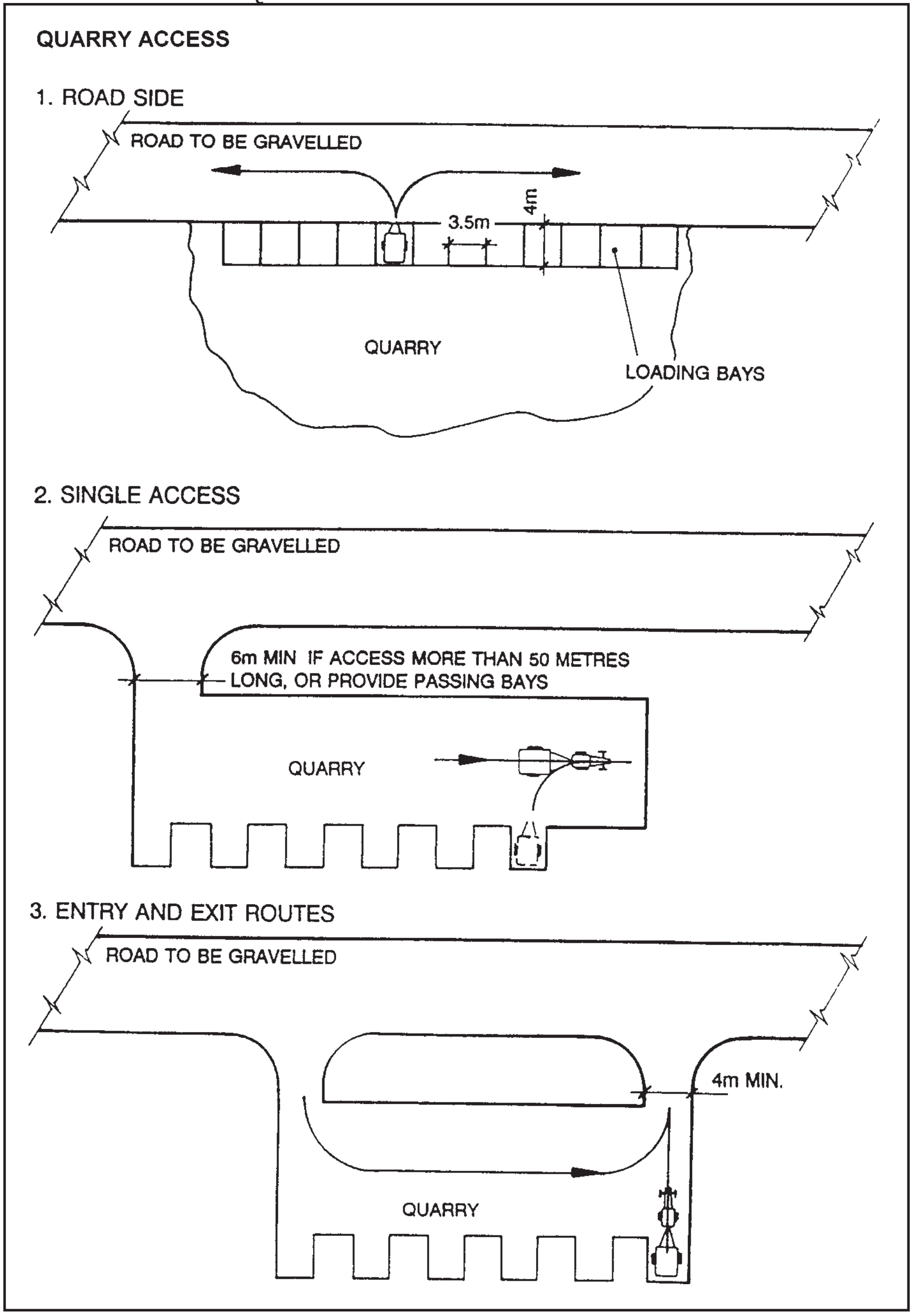
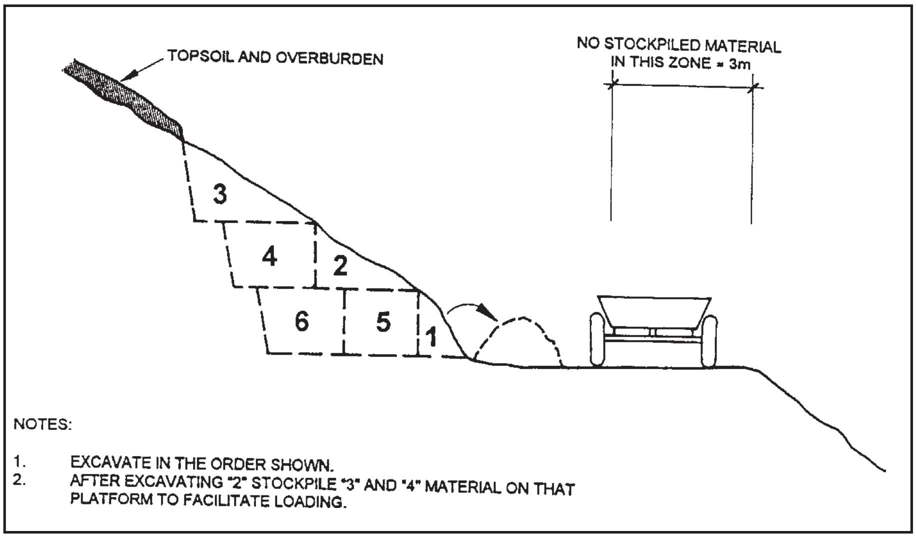


FIGURE 4 - F2.2: DEVELOPMENT OF HILLSIDE QUARRY



F2.3 GRAVELLING WORK PLANNING AND ORGANIZATION

A proper workplan for gravelling is extremely important. This plan should provide information on inputs (number of workers and equipment), productivities, outputs and timing of the work.

Always aim to organise the un-loading in such a way that waiting time for the vehicles is minimised. This implies that the supervisors need to estimate the transport time from the road site to the quarry, and based on the number of tractors/trailers or trucks available, estimate how often a tractor/trailer or truck deliver a load. This will indicate how much time is available for the spreading and levelling the gravel delivered by each truck. Ideally, the workers should be able to spread and level the gravel before a new load arrives on site.

There are two ways to organise the un-loading; gravelling towards or away from the quarry.

Gravelling towards the quarry can be organised in such a way that the vehicles have very short waiting times for un-loading, even if several vehicles unload at the same time. However, this method requires the tractor or trucks to drive over the road sections which has still not been gravelled, which may cause damage to the road, especially in rainy periods. It may even become impossible to continue the works, as the earth road may become too slippery and muddy.

Gravelling away from the quarry implies that the trucks will pass over the newly completed road sections. This method has the advantage that the vehicles frequently pass over the newly levelled gravel and thereby provide some compaction to the gravel layer. However, this method also has some disadvantages. It requires that the delivered gravel needs to be levelled before a new truck can dump its gravel and may therefore delay the un-loading. Finally, a large number of heavy traffic on the road may result is some damages to the newly constructed road.

In both the methods, it is advisable that the hauling equipment turns to the direction of the quarry before offloading so that after offloading, it can drive off without waiting for the material to be spread.

Therefore, the gravelling operation needs to be carefully planned, depending on the situation and the general conditions under which the project is working.

The daily, weekly or monthly quarry and gravelling planning can be done with the aid of tables and charts namely **Table1** to **6** of **F2.3** and **Figures 1** to **5** under this section.

TABLE 1 – F2.3: PRODUCTIVITY FOR WHEELBARROW HAULAGE

WHEELBARROW HAULAGE RATES		Wheelbarrow Haulage Productivity by haulage distance per worker day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	Estimated volume of wheelbarrow is 40 litres/trip all excluding excavation
	0 ~ 20 m	190	7.6	170	6.8	130	5.2	
	21 ~ 40 m	170	6.8	150	6.0	120	4.8	
	41 ~ 60 m	150	6.0	135	5.4	100	4.0	
	61 ~ 80 m	130	5.2	115	4.6	90	3.6	
	81 ~ 100 m	110	4.4	100	4.0	75	3.0	
	101 ~ 120 m	90	3.6	80	3.2	60	2.4	
	121 ~ 150 m	65	2.6	55	2.2	45	1.8	

TABLE 2 – F2.3: PRODUCTIVITY FOR TRACTOR HAULAGE USING TWO TRAILERS

Typical haulage rates for manually loaded tractor/trailer		Equipment Haulage Productivity by two trailers per tractor combination per day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	Estimated volume of tractor towed trailer is 3 m^3/trip
	0.0 ~ 0.5 km	37	111	34	102	30	90	
	0.6 ~ 1.0 km	30	90	26	78	21	63	
	1.1 ~ 1.5 km	25	75	21	63	16	48	
	1.1 ~ 1.5 km	25	75	21	63	16	48	
	1.6 ~ 2.0 km	21	63	18	54	13	39	
	2.1 ~ 2.5 km	18	54	15	45	11	33	
	2.6 ~ 3.0 km	16	48	13	39	10	30	
	3.1 ~ 3.5 km	15	45	12	36	8	24	
	3.6 ~ 4.0 km	13	39	10	30	7	21	
	4.1 ~ 4.5 km	12	36	10	30	7	21	
	4.6 ~ 5.0 km	11	33	9	27	6	18	

TABLE 3 – F2.3: PRODUCTIVITY FOR TRACTOR HAULAGE USING ONE TRAILER

Typical haulage rates for manually loaded tractor/trailer		Equipment Haulage Productivity by one trailer per tractor combination per day						Remarks
		Good Route		Fair Route		Poor Route		
Recommended productivity rate	Haulage distance	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	No. of Trips	Volume (m^3)	Estimated volume of tractor towed trailer is 3 m^3/trip
	0.0 ~ 0.5 km	25	75	23	69	21	63	
	0.6 ~ 1.0 km	21	63	19	57	16	48	
	1.1 ~ 1.5 km	18	54	16	48	13	39	
	1.6 ~ 2.0 km	16	48	14	42	11	33	
	2.1 ~ 2.5 km	15	45	12	36	10	30	
	2.6 ~ 3.0 km	13	39	11	33	8	24	
	3.1 ~ 3.5 km	12	36	10	30	7	21	
	3.6 ~ 4.0 km	11	33	9	27	7	21	
	4.1 ~ 4.5 km	10	30	8	24	6	18	
	4.6 ~ 5.0 km	10	30	8	24	6	18	

Table 4 – F2.3: Productivity for truck haulage

<table>
<tr><th colspan="2" rowspan="2">Typical haulage rates for manually loaded trucks</th><th colspan="6">Equipment Haulage Productivity by tipper/truck per day</th><th rowspan="2">Remarks</th></tr>
<tr><th colspan="2">Good Route</th><th colspan="2">Fair Route</th><th colspan="2">Poor Route</th></tr>
<tr><td rowspan="6">Recommended productivity rate</td><td>Haulage distance</td><td>No. of Trips</td><td>Volume (m^3)</td><td>No. of Trips</td><td>Volume (m^3)</td><td>No. of Trips</td><td>Volume (m^3)</td><td rowspan="6">Estimated volume of tipper/truck is 5 m^3/trip. The numbers of trips are applicable for all trucks with capacity of less than 10 m^3 but number of loaders will be increased.</td></tr>
<tr><td>0.0 ~ 2.0 km</td><td>22</td><td>110</td><td>18</td><td>90</td><td>16</td><td>80</td></tr>
<tr><td>2.1 ~ 4.0 km</td><td>19</td><td>95</td><td>15</td><td>75</td><td>12</td><td>60</td></tr>
<tr><td>4.1 ~ 6.0 km</td><td>16</td><td>80</td><td>12</td><td>60</td><td>10</td><td>50</td></tr>
<tr><td>6.1 ~ 8.0 km</td><td>11</td><td>55</td><td>8</td><td>40</td><td>7</td><td>35</td></tr>
<tr><td>8.1 ~ 10 km</td><td>8</td><td>40</td><td>6</td><td>30</td><td>5</td><td>25</td></tr>
</table>

Table 5 – F2.3: Productivities for compaction

COMPACTION	Average productivity rates in m^2 per day		Remarks
	Manual Compaction (max. thickness <150 mm)	Equipment Compaction (max. thickness <200 mm)	
Recommended task rate and productivity	9 m^2/wd	700 m^2/rollerday	Manual compaction with hand rammers is effective for side slopes and back filling of structure works where rollers cannot be used.

Table 6 – F2.3: Productivities for watering

WATERING	Average productivity rates per day		Remarks
	Manual Watering	Equipment Watering	
Recommended task rate and productivity	4 ~ 6 m^3/wd	5 ~ 15 trips/bowserday	Manual watering includes hauling water within source of 150m. Bowser productivity depends on distance, road condition and demand of watering. Judgement of supervisor is required.

FIGURE 1 - F2.3: GRAVELLING TARGET TRIPS PER DAY FOR TRACTORS

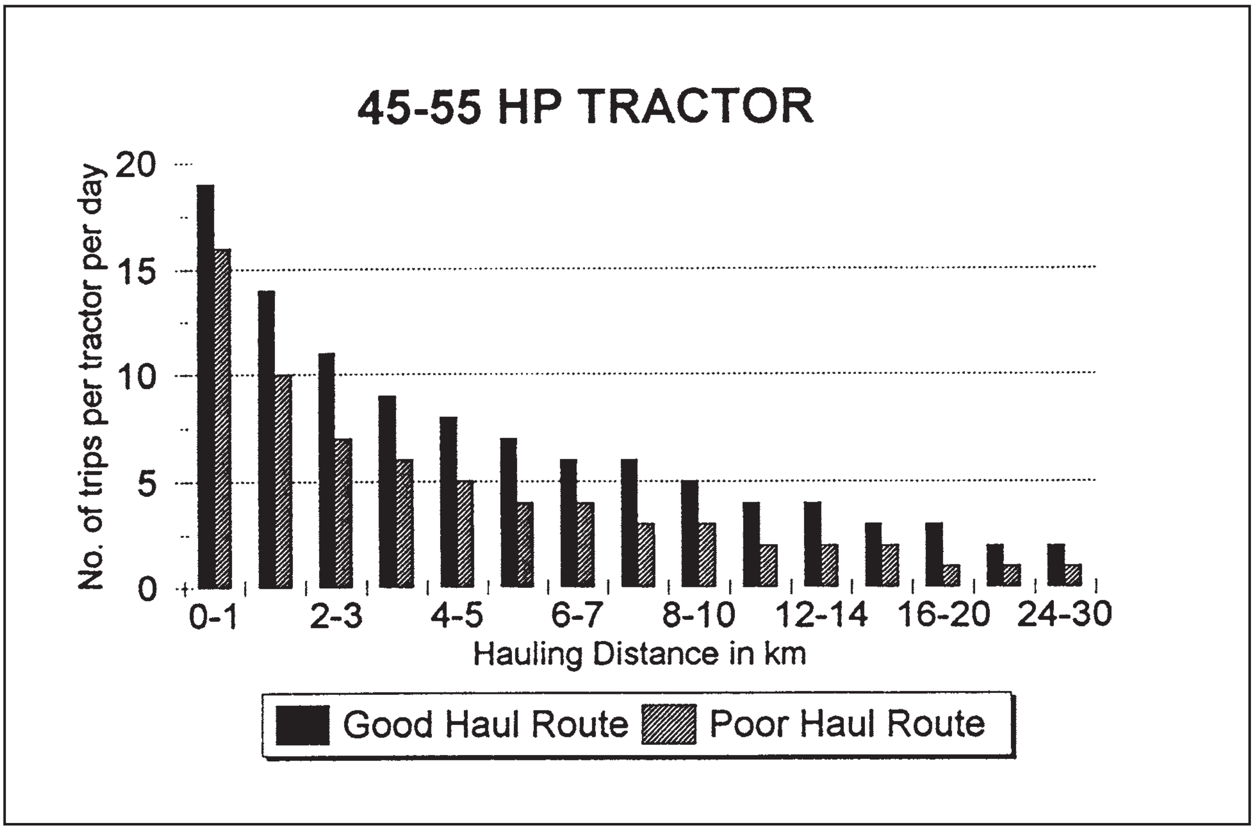


FIGURE 2 - F2.3: GRAVELLING TARGET TRIPS PER DAY FOR TRACTORS - CONTINUES

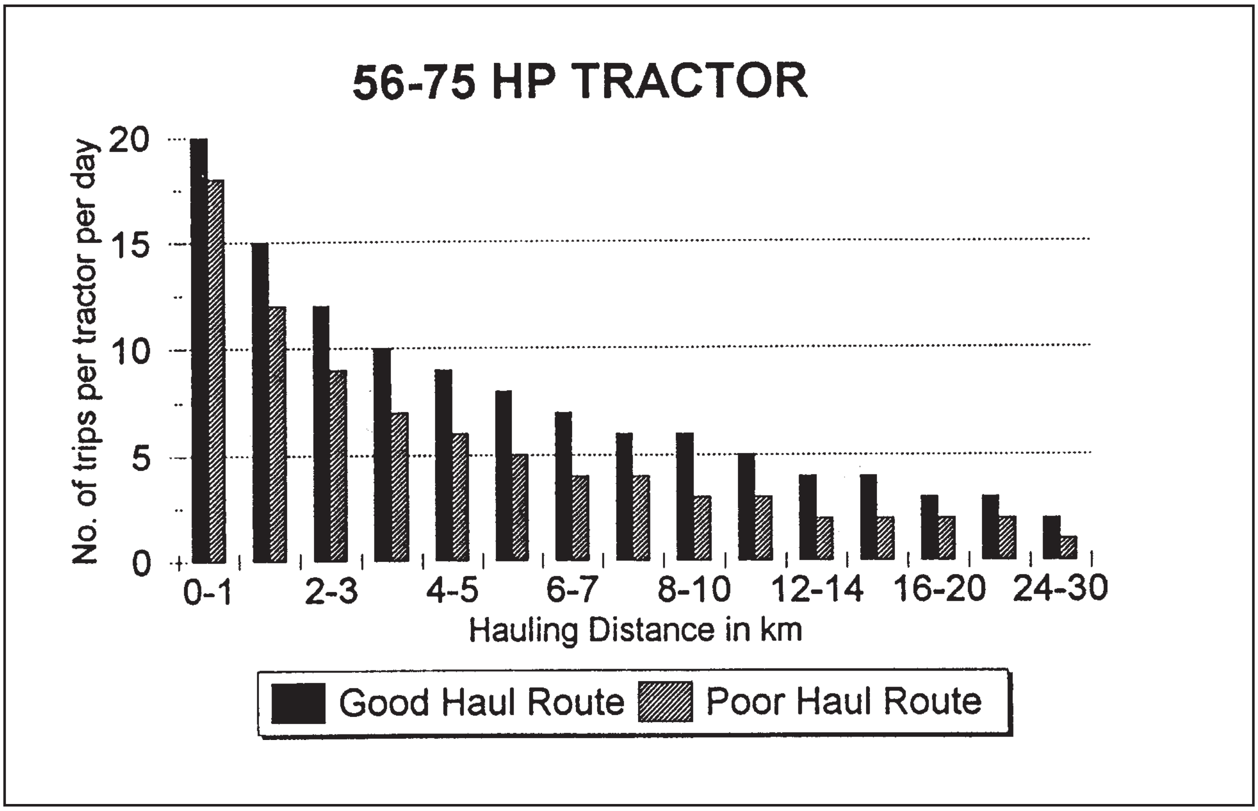


FIGURE 3 - F2.3: GRAVELLING TARGET TRIPS PER DAY FOR NON-TIPPING TRUCKS

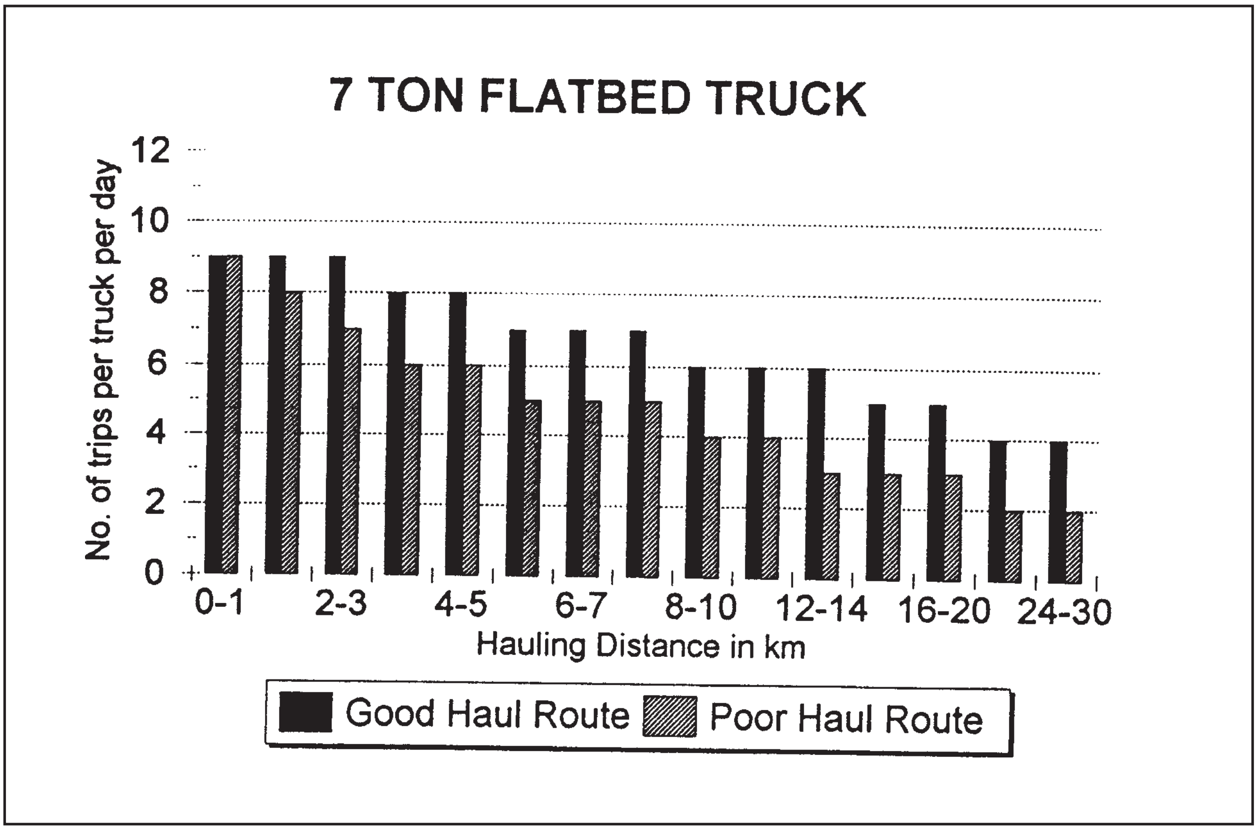


FIGURE 4 - F2.3: GRAVELLING TARGET TRIPS PER DAY FOR TIPPER TRUCKS

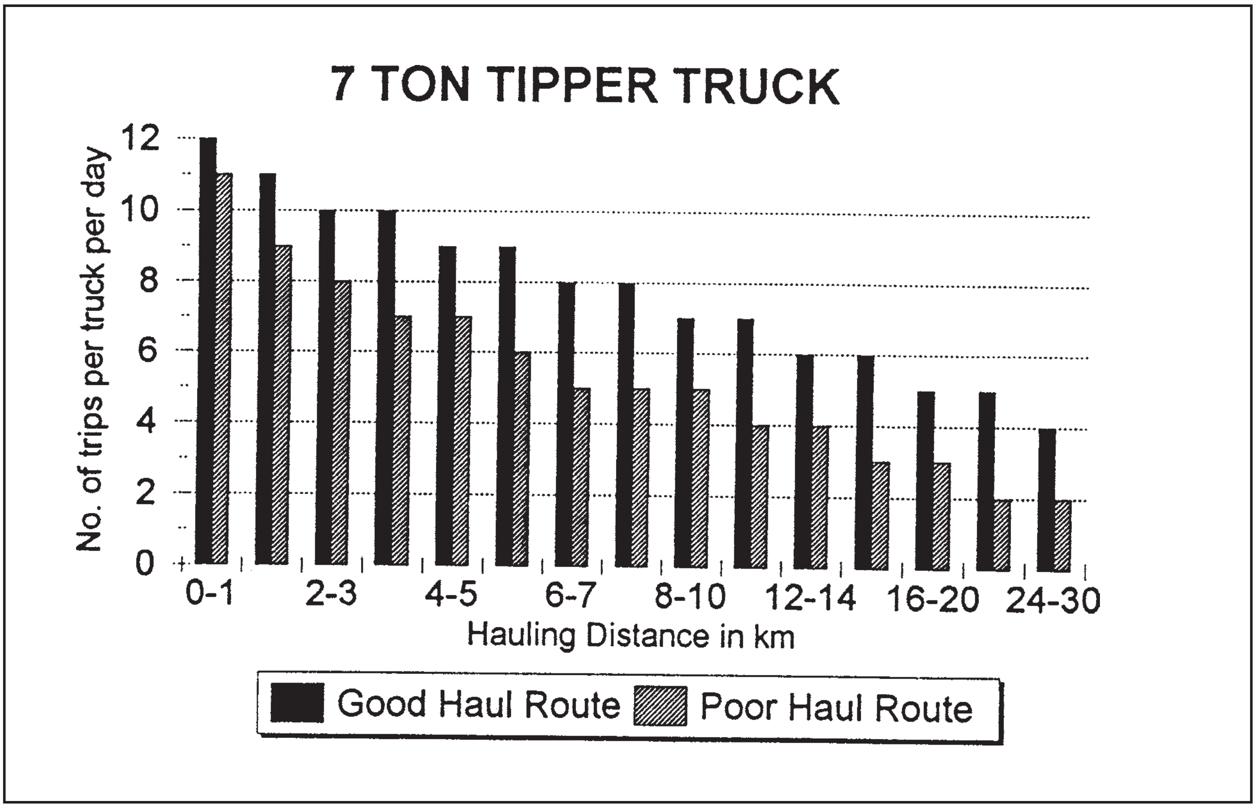
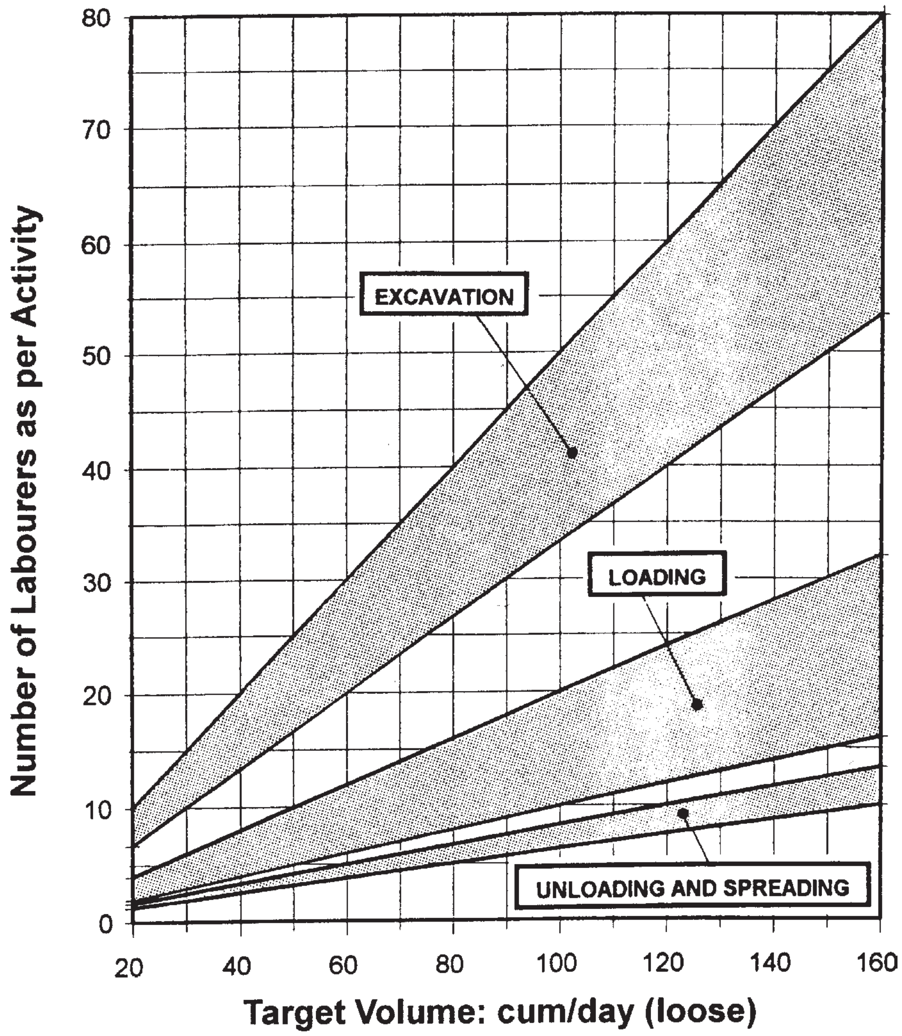


FIGURE 5 - F2.3: GRAVELLING LABOUR REQUIREMENTS



Target band shows the number of labourers required for each activity according to the quantity of (loose) gravel to be hauled during the day.

F2.4 RESHAPING

Definition

The road to be (re-)gravelled should be brought to its original cross section or shape before gravelling. The reshaping activity is therefore necessary if the road has been used for vehicular traffic for more than 1 ~ 2 weeks or is for regravelling in a periodic maintenance operation. The activity will include re-establishment of the camber cross fall, shoulders and slopes to enable the water to drain off easily. Opportunity must be given to correct other necessary drainage works such as side drains, mitres drains, culverts and scour checks.

Depending on the degree of deformation or damage to the above elements (camber, slopes, drains) the reshaping may be described as light or heavy. Reshaping may be by labour-based methods or grading by equipment. The choice of technology depends on the viability in respect of cost.

Resources

Tools (labour Based)

- Hoe or mattock
- Rake
- Camber board
- Broom
- Ditch and slope templates
- Pick axe
- Shovel
- Wheel barrow
- Hand rammer
- Spirit levels for templates
- Temporary road signs

Labour

The gang size will depend on the rate of (re-)gravelling. There must be the right number of labourers to achieve daily a length equal to that planned for gravelling per day.

Equipment

- Grader (for mechanised methods)
- Tractor and towed grader (intermediate approach)
- Vibrating rollers
- Water browser (if necessary)

Materials

- Water (if necessary)
- Pegs

Productivity

The task is given in linear meters of road. For light reshaping work, a task in linear meters of 20 to 50 per worker-day is possible. In case of heavy reshaping (as in reconstruction), tasks comparable to those in improvement works can be given for each item that forms the reshaping.

Work method

The contractor may choose to use labour-based method, equipment or a combination of both depending on the difficulty of the work, availability of equipment and cost.

Using Labour Based Methods

Reshaping using labour-based method will involve the following:

- All tools and safety items delivered to the site checked and placed respectively by the supervisor.
- Any vegetation from the carriageway or shoulder is removed using a hoe, brushed with broom, removed and dumped out on the lower side of the road.
- Trimming the surface material with hoe or mattock to restore the road surface shape, brining the materials from the sides to the centre and forming to the required camber cross-fall.
- Re-excavate and clean side drains. If the material excavated from the drains is of good quality, it is spread on the road surface otherwise it is spoilt.
- The original road surface should be scarified using pick or equipment before spreading the loose material on the surface, watered (if necessary) and compacted using a hand rammer or roller.

Quality Control

Quality control checks for reshaping consist the following:

TABLE 1 – F2.4: QUALITY CONTROL CHECKS FOR RESHAPING

Test	Method	Frequency	Tolerance
Width of formation (carriageway + shoulders)	Tape	every 100 m	+ 50 / - 20 mm
Camber (cross-fall)	Template	every 50 m	+ / - 1%
Longitudinal profile	boning rods, profile boards or by surveying instrument	every 20 m	+ / - 100 mm
Drain dimensions	Template / Tape	every 100 m	+ / - 25 mm
Mitre drains: numbers, location, dimensions and gradient	Counting, tape, line-level	all	0
Compaction	Counting passes, checking imprint of roller	completed road section	0

Environment Health and Safety

On low volume roads, traffic signs ("**people at work**" or "**road work ahead**") must be placed in either ends of the work section. If the traffic is very high, the road should be closed. Workers must also wear reflective clothings.

Care must be taken when depositing vegetation removed, or when borrowing materials to fill depression during reshaping. Any material deposited outside the road must be spread to level and must be done in such a manner to avoid incidence of contaminating water sources. Excavations of borrow material must be done in such a way as to avoid possible cause of erosion to the ground surface or ponding of water and rehabilitated if necessary.

F2.5 GRAVEL EXCAVATION AND STOCK PILING

Definition

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.

Resources

Tools

- Mattocks
- Hoes
- Pick-
- Shovels
- Wheelbarrows
- Sledgehammers
- Tape measurers

Labour

Gravel should preferable be excavated using gang tasks. The size of the gang depends on the gravelling rate, hardness of insitu gravel and productivity targets. There must be sufficient labour to excavate an equal or more volume of gravel needed ready for use in the next day. The number of labourers required for the total truck or tractor/trailer loads can be used.

Materials

- Strings
- Pegs

Productivity

Proposed task rates for gravel excavation

TABLE 1 – F2.5: PROPOSED TASK RATES FOR GRAVEL EXCAVATION

GRAVEL EXCAVATION	Average productivity by hardness of soil in (in situ volume) m^3 per worker day		Remarks
	Excavation (instu)	Excavation (loose)	
Recommended task rate	1.6 ~ 2.4m^3/wd	2 ~ 3m^3/wd	Judgement of supervisor is required.

Note that the task for very hard gravel with much oversize particles may be lower than 1.6 m^3/work-day.

Work Method

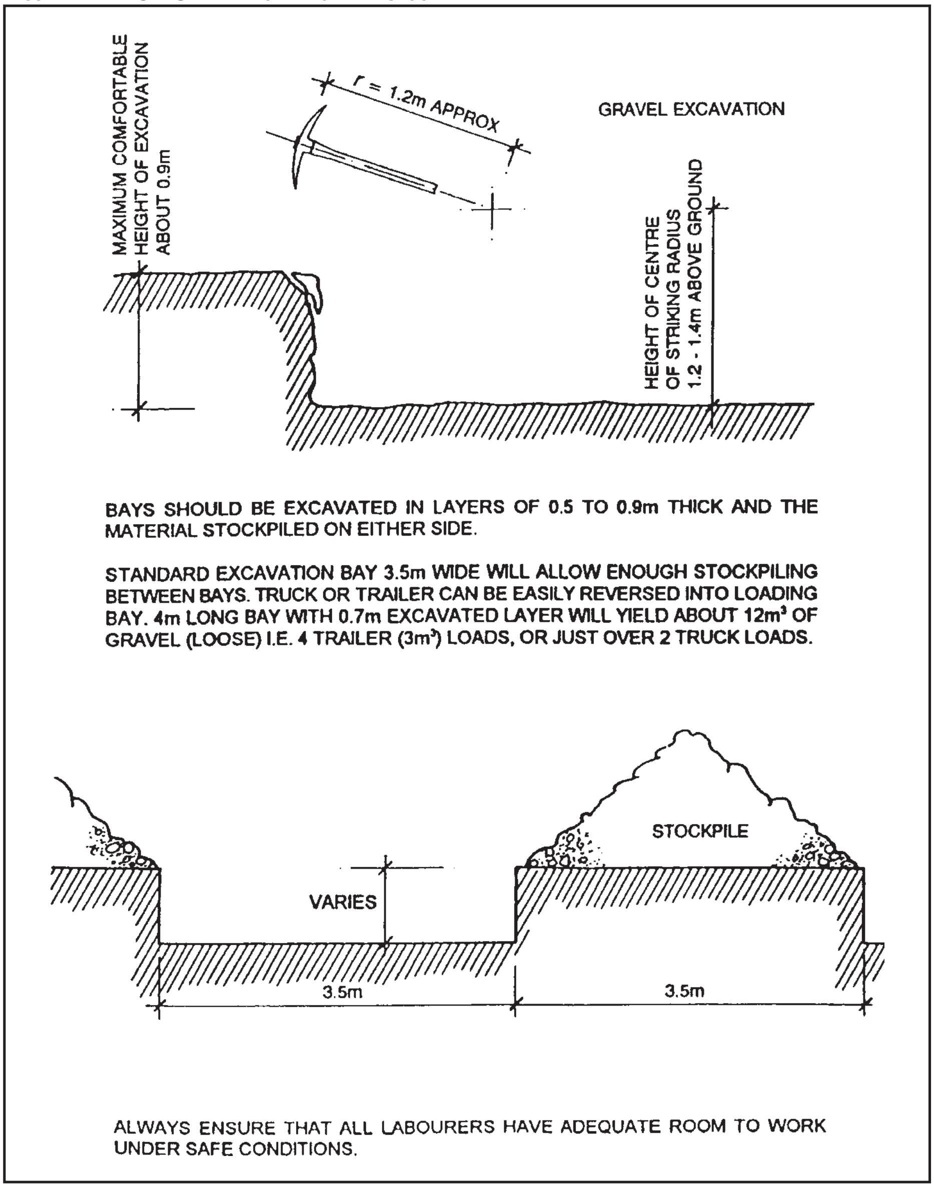
Set for gravel excavation such that it is done in bays **Figures 1**, **3** and **4** of **F2.2**. Gravel excavation is suitable for gang tasks, thus cutting down the amount of setting out and monitoring required by the foreperson.

Excavate gravel and stockpile ready for loading **Figures 3** to **7** of **F2.2**. In hillside quarries, excavate gravel to ease loading while ensuring safety of work force **Figures 9** of **F2.2**. 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 bays to allow for easy loading and avoid multiple handling.

Remove any boulders or oversize particles encountered during excavation.

Ramps into the loading bays must not be too steep for tractors hauling loaded trailers.

FIGURE 1 - F2.5: GRAVEL EXCAVATION AND STOCK PILE



Quality Control

Visual inspections are carried out to ensure that oversize particles or other unsuitable material are removed from the excavated material.

Environment, Health and Safety

Workmen must have enough room to work safely and comfortably. There must also be enough room for trucks or tractor/trailer to maneuver. In the case of hillsides high cuts must be avoided by cutting in suitable height steps.

FIGURE 2 - F2.5: EXCAVATION IN BAYS

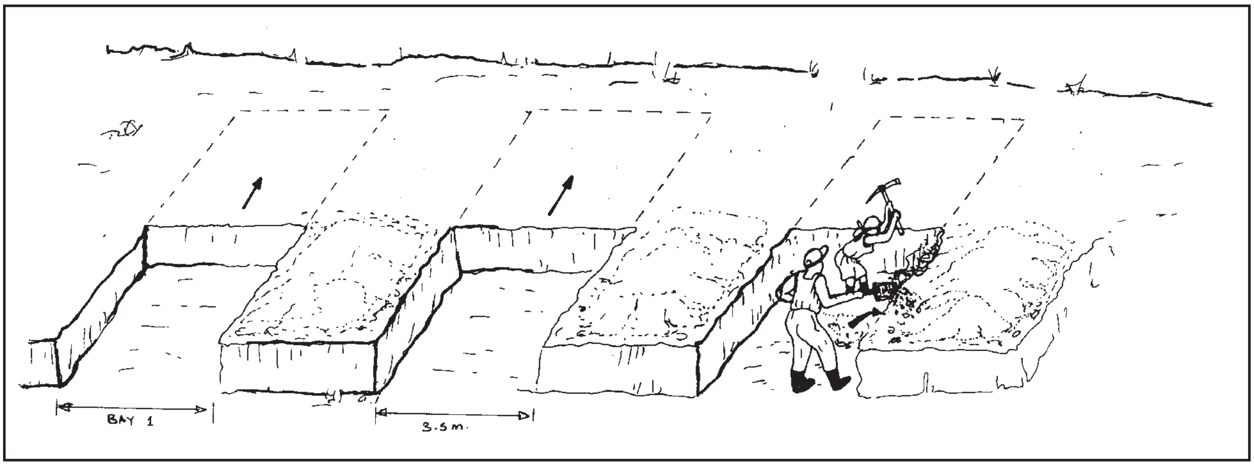


FIGURE 3 - F2.5: LOADING TRACTOR TRAINER

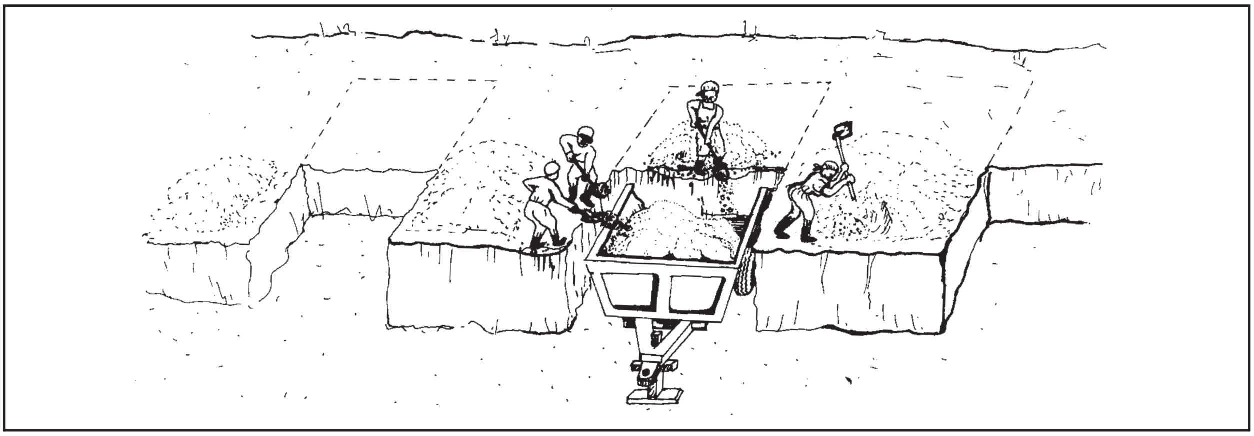


FIGURE 4 - F2.5: LOADING FROM INNER BAY

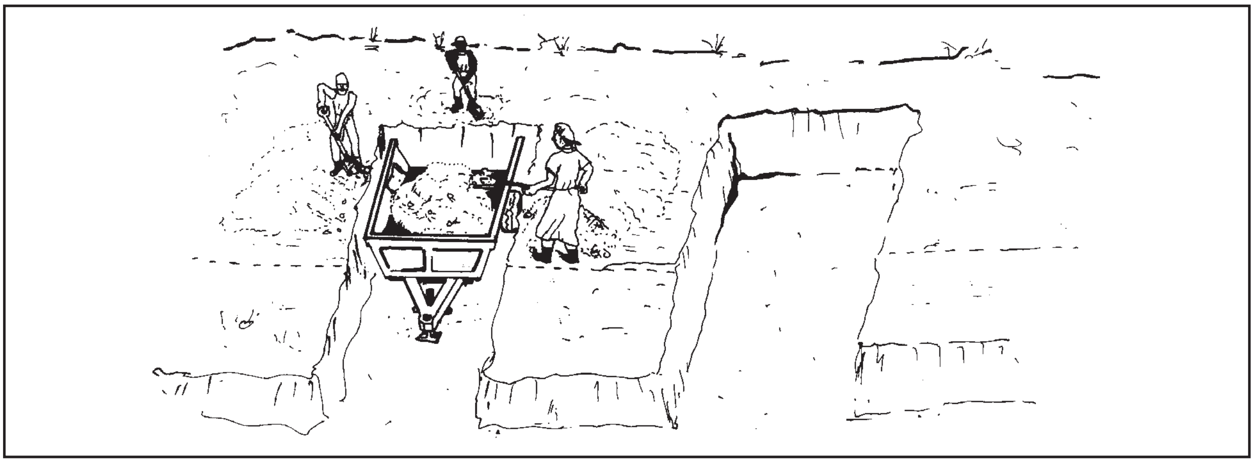
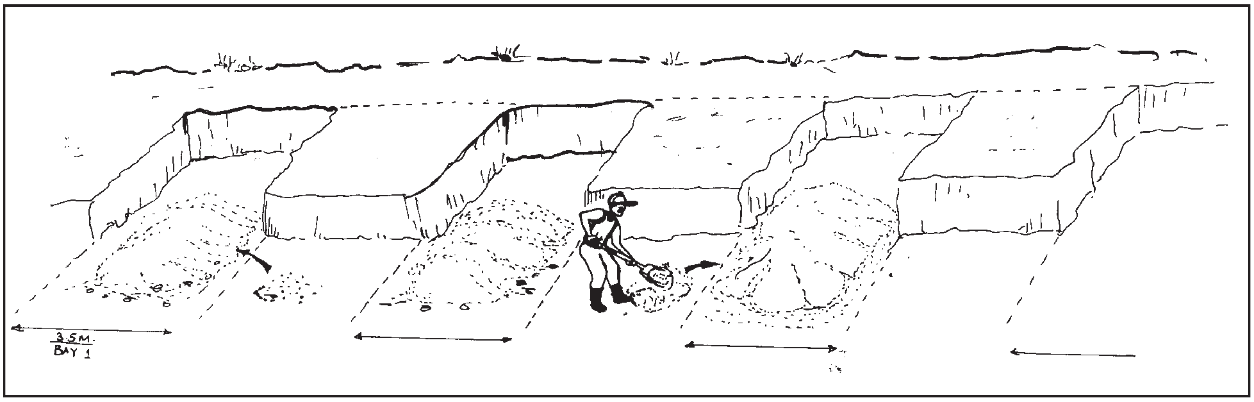


FIGURE 5 - F2.5: EXCAVATING REMAINING BAYS



F2.6 LOADING GRAVEL

Definition

This activity involves placing of excavated loose gravel from the stockpile onto the hauling equipment, i.e. truck or tractor-trailer.

Resources

Tools

- Shovel
- Hoes

Labour

The loading gang should be divided into groups of 4 to 6 labourers (refer to **Table 5-2.3** in **Section 2.3**). These groups load the empty trailers in the order in which they arrive at the site. Trucks like tractors with only one trailer stand idle while loading. Sufficient gang size for loading the truck must therefore be selected to reduce idle time.

Productivity

The proposed task rates for loading gravel

TABLE 1 – F2.6: PROPOSED TASK RATES FOR LOADING GRAVEL

LOADING STOCKPILED GRAVEL	Average productivity by hardness of soil in (in situ volume) m^3 per worker day		Remarks
	Excavation (in situ)	Excavation (loose)	
Recommended task rate	8 ~ 10 m^3/wd	5 ~ 8 m^3/wd	Judgement of supervisor is required.

Work Method

Trucks or trailers 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 trailers and trucks (see **Section F2.5**). Situations that result into the equipment being far high above the stockpile should be avoided as loading becomes difficult.

Quality Control

All trailers and trucks must be loaded to the correct load line. No oversize rock should be loaded.

Health and Safety

Workmen must have enough room to work safely and comfortably.

F2.7 HAULING GRAVEL

Definition

Hauling involves the movement of excavated material from the source to the point of use of the material.

Resources

Labour

If hauling by wheelbarrow (for distances less than 150m) labour will be required.

Equipment

- Wheelbarrow
- Tractor and Trailer (for 0.5 ~ 8 km)
- Truck (over longer distances)

Productivity

The haul distance and condition of the haul route determine the quantity of gravel to be hauled in a day by each type of working equipment.

Haulage by wheelbarrow

Refer to **Table 1** of **F2.3** for haulage by wheelbarrow.

Haulage by tractor trailer combination

The volume of gravel in each trip depends on the trailer capacity. Trials have shown that the optimum capacity for tractor trailer used in feeder road works is $3m^3$ of loose gravel. The target number of tractor/trailer loads to be hauled each day is selected from **Tables 2** and **3** of **F2.3** or from **Figures 1** and **2** of **F2.3**. Interpolations between the figures for “good” and “poor” haul routes are appropriate for average conditions. These are based on 2 trailers per tractor. If there are less than 2 serviceable trailers per tractor and tractors have to stand for idle awaiting loading, then the loading gang size may be increased to a maximum of 10 persons.

Haulage by trucks

Trucks of capacity 3 ~ 5 m^3 may be used. The 7 Ton truck of capacity $5m^3$ of loose gravel is commonly used in low volume road works. Under difficult conditions, e.g. mountainous terrain, poor haul route, strenuous quarry access, rainy season etc, this loading capacity may have to be reduced. Based on various trials, guidelines for daily target trips are given in **Table 4**, **Figure 3** and **4** of **F2.3**.

Choice of Haulage Equipment

The maximum economic hauling distance of gravel by the tractor/trailer combination is usually about 4 to 6 km. The trucks are economic for any distance upto about 20 km. (Refer to **Table 1** of **F1**).

Work Method

If possible gravelling work should start from where the quarry access joins the road to be graveled. Initially the gravelling can be done away from the quarry access in both directions because of the short hauls, this will reduce congestion at the off-loading site. When hauls exceed 1km, gravelling should continue in only one direction at a time. It is also advisable to gravel the road section where the access road meets to reduce the wear and tear of the road around the access juction. The advantages of these is that:

- The gravelling equipment compact the material as they haul over the laid gravel
- Damage to existing road camber is minimised
- Gravelling traffic does not interfere with reshaping activities
- Gravelling can restart sooner after rainfall

Tractor Trailer Hauling Operation

The hauling of gravel must be well planned to ensure efficiency and avoid any waste of resources. Ideally, one tractor works with two trailers to maximize use of the tractor. The number of tractors to be used in the day is selected after considering the quantity of gravel stockpiled ready for hauling, the haul distance, and the number of labourers available. The labourers available to each activity can be determined using the quantities to be hauled and the productivity ranges shown in **Figure 5** of **F2.3**.

Tractors and trailers are parked in the camp overnight. At the start of the workday the tractor will take an empty trailer **A** to the quarry. While trailer **A** is being loaded the tractor returns to camp to collect another empty trailer **B** and takes it to the quarry, unhitching at another bay. Trailer **A** will have been loaded and is hitched onto the tractor and hauled to the dumpsite. During this time trailer **B** is being loaded. At the dumpsite the offloading gang offloads trailer **A**. The tractor does not unhitch but waits for the trailer to be offloaded by hand (4 ~ 12 minutes depending on the trailer design). The tractor and trailer **A** return to the quarry. The empty trailer **A** is unhitched at an empty bay and the loaded trailer is hitched to the tractor. The cycle is repeated until the target number of trips is reached. At the end of the day the tractor and trailers are returned to the camp.

Truck Hauling Operations

Hauling by truck is planned and carried out following similar principles to those described above. However trucks stand idle during loading and offloading. Efficient organization of the both loading and offloading is therefore essential.

Environment Health and Safety

Care must be taken while operating equipment on site (e.g. driving, connecting the trailer etc.) to ensure safety of the workers and other traffic.

F2.8 OFF-LOADING AND SPREADING

Definition

This is a combined activity involving removal of gravel material from the equipment and spreading it to the required thickness and width. Tractor trailers often have to be offloaded by labour. Trucks may often remove their load by tipping and therefore do not require labour to offload. However flat bed trucks will be offloaded by labour in similar way as the tractor trailer.

Resources

Tools

- Shovels
- Hoes
- Rakes
- Camber board and spirit level
- Sledge hammer

Labour

Usually no more than 4 workers can comfortably work on a trailer at a time. The gang should be able to unload the 3m3 trailers in 8 minutes. With side door trailers this may be reduced to about 5 minutes.

Materials

- Strings (of sisal or nylon twine)
- Wooden pegs

Productivity

The proposed task rates for offloading and spreading

TABLE 1 - F2.8: PROPOSED TASK RATE FOR MANUALLY OFFLOADING

Activity	Task Rate
Offloading and spreading	12 ~ 16 m^3/work-day

Work Method

The off loading and spreading must be planned to ensure efficiency and spreading to be done to the correct thickness.

Tractor Trailer

The trailers must be off loaded as quickly as possible. The tractor and trailer should turn to the direction of the quarry, before unloading. In this way it can return to the quarry without waiting for the material to be spread. Provision of turning places/space for the tractor is very important for keeping cycle time.

The material from one trailer is off loaded and spread within a "**box**" marked out by pegs and string. The pegs are set at the center line and edges of the box with the aid of camber board and spirit level to ensure satisfactory cross fall (of 8%) and the longitudinal gradient checked using boning rods.

The width of the box is equal to the carriage way width to be graveled and its length can be calculated according to the bucket capacity (i.e. capacity of the trailer) to ensure that material is spread to the correct loose thickness. See formula below.

$$\textbf{Length of Box} = \frac{\textbf{trailer/bucket capacity}}{\textbf{road gravelled width x layer thickness}}$$

Trailer capacity must therefore be carefully checked and estimated by the engineer or supervisor.

Any gravel lumps or stones larger than 5 cm (oversize) should be broken down using sledge hammers, or removed.

Tipper Truck

Tipper trucks will be offloaded into the spread "box" with the vehicle moving slowly forward to distribute the material as far as possible along the length of the box. The tipper or truck should turn to the direction of the quarry, before unloading. In this way it can return to the quarry without waiting for the material to be spread.

Quality Control

TABLE 2 – F2.8: THE QUALITY CONTROL CHECKS FOR SPREADING

Test	Method	Frequency	Tolerance
Gravel Surface Width	Tape	every 100 m	- 20 mm
Gravel Surface Thickness	Test holes, Tape	spot checks, average 5/ km	- 10 mm
Gravel Surface Profile	Camber Board	every 50 m	+ / - 1%

Environment, Health and Safety

Workers must have enough space to work safely and comfortably. On low volume roads, traffic signs ('**men at work**') must be placed in either ends of the work section. If the traffic is very high, the road should be closed. Workers must wear reflective clothes.

F2.9 COMPACTION

Definition

This activity involves densifying the loose grave material to levels (degrees) desired by specifications, by applying dead or dynamic vibratory load. Compaction should be done by the appropriate method or equipment to suite the work specifications and conditions.

Resources

Tools

- Rammers (if done by labour)
- Watering cans (if done by labour)

Equipment

- Rollers
- Water-bowser
- Tractor

Labour

This will depend on the area to be compacted. Normally a gang of one or two workers will be required for adding gravel where any correction/ adjustment is required.

Materials

- Water

Productivity

The productivity of the compaction equipment is determined by the type (pedestrian or self propelled), compactive-effort, the material (thickness and quality) and the designed degree of compaction.

Work Method

Compaction should be carried out with a vibrating roller with approved total weight and dimension.

Before applying the compaction equipment, the gravel is laid evenly and the surface smoothness longitudinal and transverse checked, watered (to achieve approximate optimum moisture content) using towed bowsers fitted with a sprinkler bar or by labour using watering cans.

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 recognised. It should be noted that the standard specification as per the contract data should be achieved regardless of the number of roller passes. Each gravel layers to be compacted should normally not exceed 20 cm loose. The camber of the compacted formation should be checked to ensure it doses not exceed a crossfall of 8% or that specified by the design.

Quality Control

TABLE 1 – F2.9: QUALITY CONTROL CHECKS FOR COMPACTION

Test	Method	Frequency	Tolerance
Gravel Surface Width	Tape	every 100 m	- 20 mm
Gravel Surface Thickness	Test holes, Tape	spot checks, average 5/ km	- 10 mm
Gravel Surface Profile	Camber Board	every 50 m	+ / - 1%
Compaction	Roller Imprint	randomly	> 95%

Environment, Health and Safety

The roller operator should wear a ear muffs at all time when operating the rollers. No children should be allowed near a moving roller and all workers should stay clear from the path where the roller is operating.

F2.10 QUARRY REHABILITATION

Definition

After the gravelling work has been completed and the quarry is not required by the contractor, the site should be rehabilitated or improved to the satisfaction of the owner and environment officer. The ground shall be levelled; topsoil hauled back and uniformly spread over the entire exposed/excavation area.

Resources

Tools

- Shovels
- Hoes
- Rakes
- Sledge hammer
- Boning rods
- Wheelbarrows

Materials

- Strings (of sisal or nylon twine)
- Wooden pegs
- Seedlings or plants

Labour

The size of gang depends on the size of the quarry.

Work Method

The Contractor may choose to use Labour to carry out this Item depending on the degree of difficulty of the work. The rehabilitation will often involve cutting back deep slopes as may be directed by the Engineer. The material from both the cut slopes is spread on the on the bottom of the quarry pit. The overburden material is also loosened, loaded and hauled using wheel barrows and spread uniformly on the exposed or excavated surfaces of the borrow pit. Plant grass on the exposed surface and that erosion control measures are constructed where necessary. All depressions should be filled in a manner to avoid ponding of water. Where there are long steep surfaces it should be terraced and then planted with grass.

Table 1 – F2.10: Quality control checks for quarry rehabilitation

Test	Method	Frequency	Tolerance
Check	Visual	all	none

Quality Control

Environment, Health and Safety

Workers must have enough room to work safely and comfortably. An environmental certificate must be given to show that the work has been done satisfactorily.

F.3 ALTERNATIVE SURFACING

Sometimes, it may not be possible to find gravel of satisfactory quality close to the road site. A number of alternatives exist to gravel surfacing. In certain circumstances the use of these may be feasible and economical.

The alternatives are:

- Hand packed stone
- Concrete running strips
- Insitu concrete slab
- Concrete block paving
- Concrete running strips

Furthermore a gravel running surface may be strengthened or protected by a number of treatments:

- Geotextile reinforcement
- Lime stabilization of subsoil
- Surface dressing
- Slurry seal

The use of these alternative labour based techniques is described in outline only in this module.

The recommendations for some of the techniques are provisional pending further research and development work. However hand packed stone and surface dressing are well proven and widely used techniques.

It may be appropriate to apply these techniques to a complete road, or just to short problem sections such as:

- Steep gradients
- Sections through villages
- Approaches to drifts
- Over black cotton soil
- High rainfall areas with long gravel hauls

If used over short sections the overall cost of the road may not be increased significantly, yet later maintenance requirements may be greatly reduced.

The following **Table 1-F3** gives an indication of the initial cost of the alternative treatment/surfacing compared to the provision of a standard 0.12 m gravel surfacing with a 5 km haul distance. It should also be appreciated that most of these alternatives will have significantly lower periodic maintenance requirements and costs.

These treatments require additional supervision to achieve an adequate construction quality and arrangements must be made to ensure this. The Engineer must also ensure that the Contractor or foreman responsible is trained and able to organize and supervise the works.

Sections of road to be constructed using any of the alternative surfacing/treatments should be detailed in the annual plan and contract documents.

TABLE 1: - F3 COST INDICATION FOR ALTERNATE SURFACING/TREATMENTS

SURFACING/TREATMENT	INDICATIVE FACTOR : INITIAL COST	REMARKS
120 mm Gravel Layer, 5 km Haul 20 km Haul 40 km Haul 200 mm Gravel Layer, 5 km Haul	 1.0 2.1 3.2 1.7	 Using Tractor + Trailers Using Tipper Haulage Using Tipper Haulage Using Tractor + Trailers
Hand packed stone, 10 km Haul	1.5	
Concrete running strips	5.0	Unreinforced
3.5 m Insitu concrete slab	10.0	Reinforced
3.5 m Concrete block paving	9.0	Including kerbs
Lime stabilisation 150 mm x 6.5 m	2.8	4% Lime
Bitumun prime, seal and clipping surface	3.5	Excluding base works

NOTE:

- Factor compares unit costs to that of a 0.12 m x 5.4 m Gravel layer with a 5 km haul. Width of surface 5.4 m unless otherwise indicated.
- Hand packed stone and manual bitumen sealing are proven labour-based techniques.

BITUMEN SEALS

Surface dressing consists of spraying the road surface with a film of binder (usually bitumen) followed by the application of a layer of stone chippings which is then rolled lightly into the surface. Surface dressing has three main purposes:

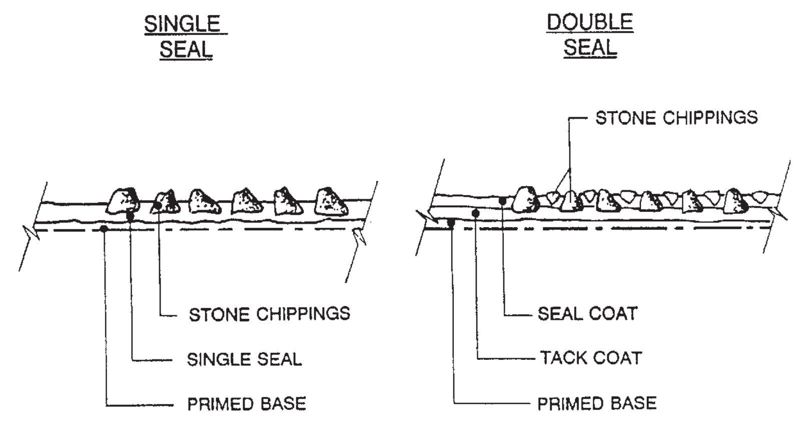
1. to seal the road surface against water
2. to prevent disintegration of the surface
3. to provide a non-skid wearing surface

Surface dressing will not restore the riding quality of misshapen roads nor will it significantly strengthen the road structure.

For this reason surface dressing must be applied to a stable and well prepared gravel base which will not deform under future traffic loads. The gravel base should be compacted and, in some cases, may need stabilization with lime to reduce its plasticity.

Surface dressing may be "**Single Seal**" or "**Double Seal**". Single seal is only appropriate for light traffic (i.e. <100 VPD). Double seal is appropriate for medium to heavy traffic and for situations such as steep hills where surface abrasion by traffic is high. The seals consist of the following layers as shown in **Figure 1-F3**.

FIGURE 1: - F3 SURFACE DRESSING



The prime is low viscosity, and is necessary on new surface to help bind the surface of the base, to penetrate and seal the surface voids in the base and to assist adhesion of the following seal.

The main and seal coats will be of more viscous bitumen (usually cut back grades).

The procedure for a double seal surface dressing is:

- After preparing, shaping and compacting the base course, dampen the surface
- When the surface is nearly dry, brush it clean of dust and loose stones.
- Ensure that the bitumen is heated to the correct temperature recommended by the manufacturer or Reference 10. It is essential not to overheat bitumen products. Apply the prime evenly with a spraying machine using a smooth steady action with the hand lance.
- One day later, spray the tack coat, again take care not to overheat the bitumen. Immediately spread an even layer of clean stone chippings using shovels. The stones can be taken from stockpiles previously placed at the side of the road, or cast from the back of a truck reversing very slowly over the freshly laid bitumen and stone.

  Attention must be paid to ensure that the stone coverage is 100% and uniform. A slight excess of stones may be tolerated. Gently roll the surface or roller to achieve an even layer of chippings (one stone thick) over the bitumen surface. A light steel drum roller may be used (non-vibrating) but crushing of the stones must be avoided.

- Next day brush off and collect surplus stone chippings.
- Allow traffic to run on this surface for about one week. Brushing of the surface to achieve an even layer of stones can continue.
- Apply the seal coat in a similar manner to the tack coat.

If spraying equipment is not available, the bitumen may be carefully heated and applied by hand using a fixed quantity of bitumen to previous marked areas. Reference 18 gives guidance on hand application of bitumen seals.

Bitumen emulsion is best suited to hand spraying applications as it does not require heating before use. Emulsions consist of bitumen droplets mixed with water in such a way that, when applied, the water evaporates leaving the bitumen to perform as a normal penetration grad. The choice of emulsions should be made with regard to the type of stone being used and reference to the suppliers. The following categories will be suitable for most applications in Uganda.

Prime Coat: MC30 or Colas Prime

Seal and Task Coats: K1-60 (Rapid Setting)

It should be noted that bitumen emulsions have a limited shelf life. They should normally be used within 6 months of purchase. Drums should be rolled to mix the contents thoroughly before use if they have been stored for any period.

Application rates should be determined through experience, however for emulsions they are likely to be in the following ranges as shown in **Table 2-F3**.

TABLE 2: - F3 EMULSION APPLICATION RATES

	SINGLE SEAL litres/m²	DOUBLE SEAL litres/m²
Prime	0.85 ~ 1.10	0.80 ~ 1.10
Tack coat	1.30 ~ 1:70	0.75 ~ 1.30
Seal coat	-	1.75 ~ 1.95

These rates a higher than for straight run or cut back bitumen grades due to the lower initial bitumen content of emulsions.

Stone chippings for single seal should be either 10 mm or 14 mm size. For double seal a larger size should be used for the tack coat and a smaller size for the seal coat.

Suitable combinations are: 10mm/6mm; 14mm/6mm; or 20mm/10mm. Approximate spread rates are shown in **Table 3-F3**.

TABLE 3: - F3 CHIPPING SPREAD RATES

SIZE in mm	m²	m³
6	130	170
10	100	130
14	80	110
20	60	85

The stones must be clean and dust free otherwise they will not adhere to the bitumen.

On a good surface dressing the stone should protrude no more than about ¼ of their size above the bitumen seal. If they protrude more than ½ of their size then there will be a high risk than the stones will whip off when trafficked.

If too much bitumen has been applied, the surface will "bleed", become less stable and the loss in surface texture will lead to low skid resistance. In extreme cases the seal will stick to the tyres of vehicles.

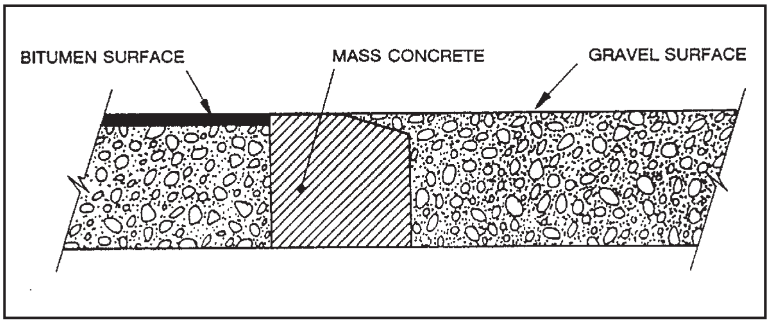
Edge thickening

To protect the edges of the surface dressing from "picking up" under traffic and to provide lateral strength, the edges of the seal may be thickened. To achieve this, narrow trenches approximately 100mm x 75mm deep are excavated along the line of the intended seal edge. They are primed along with the rest of the road surface. The trenches are than packed with clean ballast of size up to 30 mm and grouted with bitumen emulsion. This technique adds cost to the surfacing however a more stable edge is given to the bitumen seal.

Lateral strips

Where short sections of bitumen surfacing are used on a gravel road, consideration should be given to the provision of lateral concrete strips at the beginning and end of the section. This will reduce damage to the edges of the bitumen. Mass concrete strips 150 mm x 150 mm with a slightly sloping top edge have been found successful.

FIGURE 2: - F3 LATERAL STRIPS



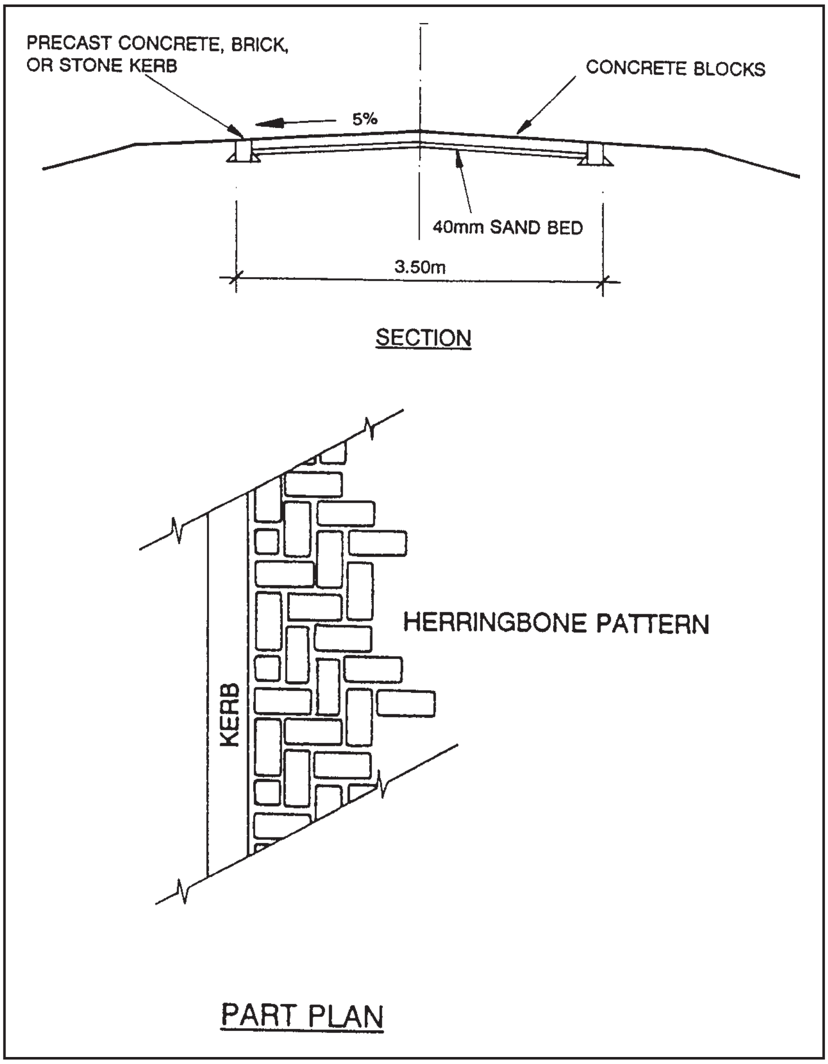
Slurry sealing

This is an alternative to surface dressing Sand, small stone and bitumen emulsion are mixed in a concrete mixer in set proportions with a small amount of cement as a catalyst it is then wheel barrowed to the site and tipped onto the previously primed gravel surface. It is immediately spread with squeegees (spreading board with a handle) to form a thin continuous layer over the gravel surface.

The bitumen provides the seal and the aggregate particles give the thin film strengrh to resist traffic loads. It is often used as an overlay to existing bitumen seals because of its ability to fill cracks and smooth out minor depressions.

CONCRETE BLOCK PAVING

FIGURE 3: - F3 CONCRETE BLOCK PAVEMENT



As with other forms of concrete surfacing, concrete block paving is expensive, although maintenance requirements are normally low.

In some circumstances on feeder roads a concrete block paving of 3.5 metres single track width may be justified. The concrete blocks should be cast on or close to site using hand moulds. They should be of nominal dimensions 200 x 100 x 80 mm or similar. The blocks must be between pre-cast concrete or cast-insitu kerbs to act as edge restraints.

The actual concrete blocks should be laid in a herringbone pattern on a 40 mm thick bed of clean sharp sand on the previously shaped and well compacted earth road profile. The blocks are vibrated to final level using a small plate compactor. Further sand is then brushed into the joints to key the blocks together.

Great care is needed in control of the quality of the concrete kerb and block casting and curing to ensure blocks of adequate strength (Class 20). A testing regime should be established to ensure this.

CONCRETE RUNNING STRIPS

Concrete provides a good quality durable running surface with low maintenance requirements if properly constructed. However it is expensive.

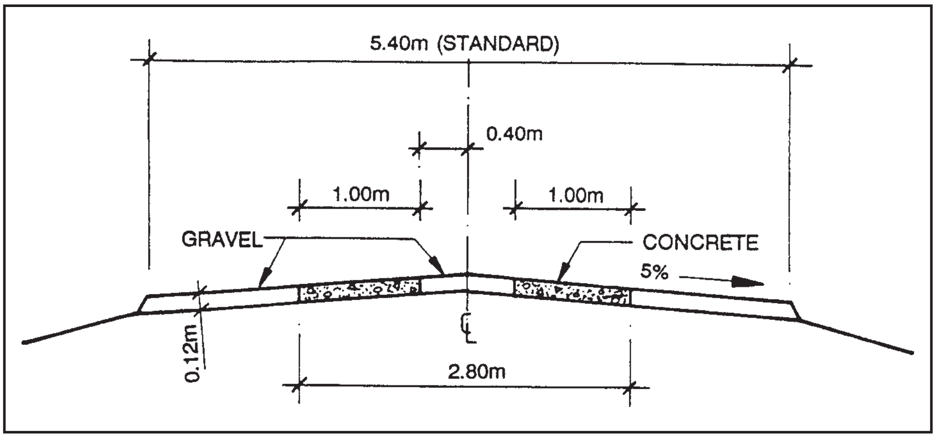
By concreting only running strips for the vehicle tyres a less costly surface is provided, suitable for light traffic of up to 100 VPD. The rest of the running surface is left as gravel. Vehicles normally run in the centre of the road. When they pass in opposite directions they move their outer wheels onto the gravel surface.

The concrete (Class 20) can be mixed by hand on site using gauge boxes and a portable mixing surface: steel, plywood sheets or the deck of a gravel haulage trailer. A motor mixer may also be used if this is available. A truck or tractor trailer and water bowser will be required at the site to haul aggregates, water and cement, and transport shutters. Concrete should be carried from mixing point to location of placing by wheel barrow (up to 200 metres).

Prior to concreting it is essential that good compaction is carried out, e.g. using a 5 tone towed dead-weight roller, or pedestrian vibrating roller.

The 120 mm concrete strips should be cast using wooden or steel formwork temporarily staked into the dry, pre-shaped and compacted earth road profile. The concrete should be tamped finished with low transverse ridges to assist sideways drainage of rainwater and provide surface grip.

FIGURE 4: - F3 CONCRETE STRIP RUNNING SURFACE



An expansion joint should be cast every 10 metres in each strip to minimize the potential for cracking under traffic. A thin strip of fibreboard, hand board or polythene sheet may be used for this. Particular care must be taken to ensure good quality construction, especially at the joints.

Curing should be carried out in accordance with the standards. After 7 days of curing the formwork may be removed and gravel placed between and outside of the concrete strips to form the finished road profile.

This technique should not be used on black cotton or other weak soils.

Maintenance

The concrete strips themselves should require little maintenance as long as the gravel surface either side is maintained. Any broken pieces of concrete strip should be promptly repaired with fresh concrete.

It is important to keep the adjacent gravel surface flush with the running strips to avoid erosion and undermining. Reshaping, grading and replenishment of this gravel will be required.

INSITU CONCRETE SLAB

If a concrete slab were to be provided for two way traffic it would need to be 5.4 metres wide or more. However the low traffic flows on feeder roads would rarely justify the considerable expense of a full width slab. In some circumstances a single track slab of width 3.5 metres may be justified.

This should be constructed using similar techniques to the concrete strips. However the slab thickness should be increased to 150 mm and a single layer of steel mesh should be fixed 50mm above the base of the slab prior to concrete pouring. Care should be taken that the mesh does not rise during concreting.

Particular care must be taken to ensure good quality at all stages of construction, and especially at the joints. The edges of the slabs at joints are subjected to vertical impact loading as heavy vehicle wheels move from one slab to the next. Steel dowels may be required to resist these loadings.

HANDPACKED STONES

In areas where stones and small boulders are common, or a stone quarry exists, hand packed stone can be a cheap alternative to gravel surfacing with long haulage distances. The stones can be collected or purchased and transported by tractor and trailer or tipper up to about 10 km if necessary. Property constructed hand packed stone will resist traffic and weather better than a gravel surface and is significantly cheaper than other alternative surfaces

A layer of stones is placed on the shaped and compacted earth road profile. A cross fall of 5% is ideal and slight rounding of the crown of the road is allowable. The layer thickness should depend on the size of stone available however a thickness of 150 ~ 200 mm is ideal, using stones of approximately the small size. The stones will require an edge restraint or "kerb" of natural stone to resist the lateral traffic.

Application

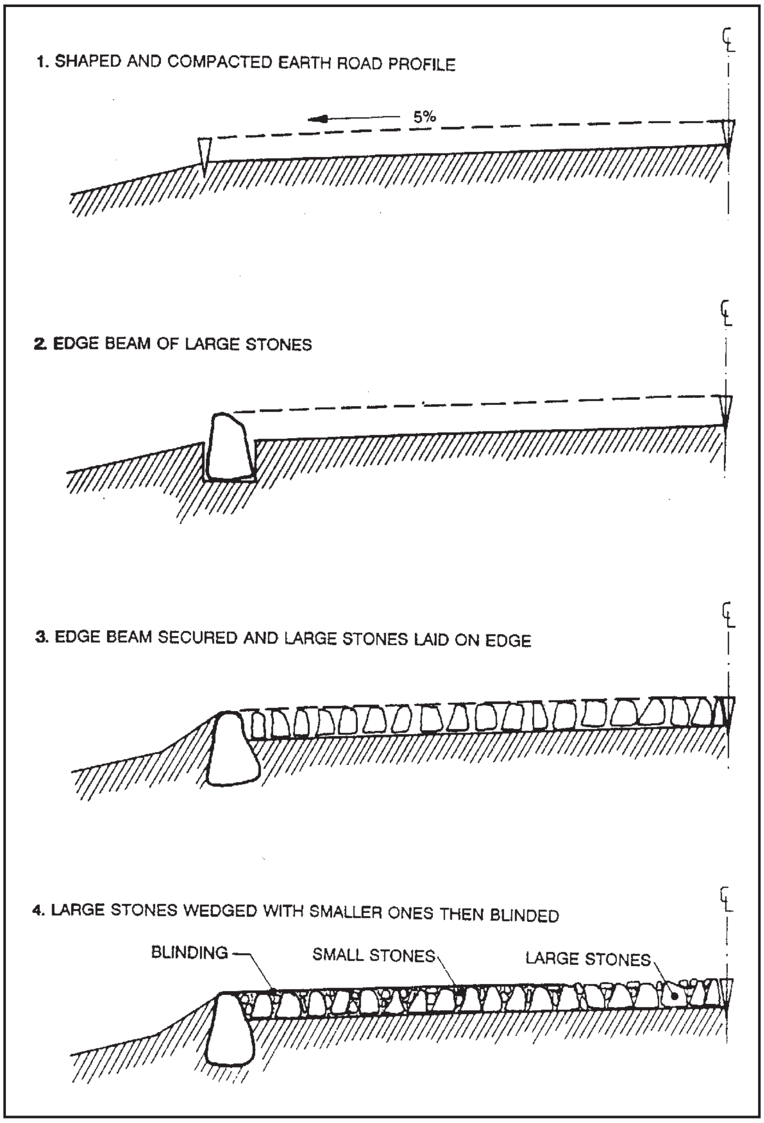
Pegs should be placed at 5 metre centers at the centerline and edge of running surface and the alignment checked as described in **Section F-2.8**. The top of the pegs should correspond with the desired finished road level.

The hand packed stone will require an edge restraint. This is provided by constructing a "**kerb**" of larger stones coincides with finished road level or just below. Soil should be backfilled and rammed around the beam stones to secure them in place.

The hand packed stone paving in next laid using the level pegs as guides. The largest stones should be placed on the ground first of all with their largest dimension vertical. They should be placed tightly together. The tops of the stones should all approximate with the finished road level or just below. The care with which this is carried out will determine the quality of the finished road surface. Masons hammers and packing pieces will be useful in adjusting the finished level of individual stones.

The level of each 5 metre bay should be checked with a 2 metres straight edge and adjusted before moving onto the next stage. This consists of filling the gaps between individual stones with smaller pieces of stone, ramming them into place. Large angular chippings from the breaking of the larger stones

FIGURE 5: - F3 HAND PACKED STONE PAVEMENT



will ideal in wedging them together. Finally the area should be blinded to finished road profile with gravel, fine stones, sand or a clay-sand mixture. The infill material should be hand rammed and material added or removed to form the final profile (checked with a straight edge). A follow up rolling with a dead weight or vibrating roller will be beneficial.

Maintenance

If potholes develop, then the area of the hole should be cleaned out. Stones must be taken out to form a clean and roughly circular hole with vertical sides. The base of the hole should be covered with the large stones and these should be wedged in place with smaller ones. The area should be blinded off with small material and compacted to slightly above (20 ~ 30 mm) the surrounding road level to allow for subsequent consolidation by traffic.

Maintenance grading should **NOT** be carried out as this will damage the road surface or the grader.

As the fine material is washed or sucked a way by the action of weather and traffic it will need to be topped up from time to time with gravel or sandy soil material. If this is not done there will be an increased risk of the large stones being lost and potholes developing.

Hand packed stone can act as suitable road base if the road is to be later upgraded to bitumen standard.

OTHER CHEMICAL STABILIZATION

Lime stabilization

Lime has been used since the 1940's in many countries for the strengthening or stabilization of road making materials.

The potential uses on the District Road Work are of stabilizing weak clay subgrade (e.g. black cotton soils) prior to the application of the gravel layer, and stabilization of highly plastic gravels prior to sealing with a bituminous surface.

Lime is not suitable for stabilizing running surface gravel as traffic will wear down the gravel surface and it cannot be reshaped without scarifying and crushing.

Lime stabilization by between 2% and 4% by weight can bring about the following improvements in materials with a significant clay/silt fraction:

- CBR increase
- Plastic limit increases
- Plasticity decreases
- Improved stability against swell and shrinkage

Trial could be carried out to determine the costs and effectiveness of lime stabilization.

Textile reinforcement

Where gravel is placed on a weak subsoil foundation the passage of traffic can rapidly lead to failure and mixing of the gravel and subsoil material Reshaping of the surface will not restore the strength of the contaminated gravel.

One solution to this problem is to place a textile reinforcement mat between the weak subsoil and the gravel. The mat helps to spread the wheel loads and acts as a separation layer between the soil and gravel surfacing.

Purpose made textile mats are available in some countries; however the importation of these would be too expensive for use on the District Road Work. Trials could be carried out to determine the costs and effectiveness of locally made sack textiles.

The potential application is for roads on black cotton soils.

Section G

Road Maintenance

Section G
Road Maintenance

ROAD MAINTENANCE

G1 DEFINITION AND TYPES OF ROAD MAINTENANCE

DEFINITION

Road management includes managing road construction projects, managing road operation or use, and managing its preservation by maintenance.

Road maintenance involves interventions or works required to keep the road, its structures and property within the road margins as near as possible to their as-constructed or rehabilitated condititon.

The continuous need for maintenance interventions tend to be more complex than construction and often difficult to predict. In effect this makes maintenance more of a process than project which requires the following management process issues:

- Delivering a defined quality of service
- Resources of people, materials and equipment
- Activities and procedures
- Location on the road network
- Timing of interventions

THE PURPOSE OF MAINTENANCE

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

The purpose of road maintenance is to ensure that the road remains serviceable until the end of its design life. Maintenance therefore performs the important function of:

- Prolonging the life of the road by reducing the rate of deterioration, thereby safeguard previous investments in construction and rehabilitation
- Lowering the cost of operating vehicles on the road by providing a smooth running surface
- Keeping the road open on a continuous basis by preventing it from becoming impassable.

TYPES OF MAINTENANCE

Road Maintenance operations are usually grouped according to planning, organisational and funding arrangments. They can normally be categorised as either Routine, Periodic and Emergence maintenance operations.

ROUTINE MAINTENANCE

These are normally small-scale operations with limited resource requirements and are usually performed regularly on a section of road. Routine maintenance consists of relatively simple activities mainly performed by labour, except grading, which may be a mechanised operation.

It is necessary to define all routine maintenance activities clearly in order to:

- Quantify the activities
- Instruct the activities to the maintenance personnel
- Control and monitor the activities effectively

The need for routine maintenance activities must be estimated and the execution of the work must be planned and controlled.

The checklist below is for routine maintenance activities on unpaved and paved roads in approximate order of priority although this can differ from case to case.

Routine Maintenance Activities for Unpaved Roads

1. Inspection and removal of obstacles
2. Cleaning of drainage structures and their inlets and outlets
3. Repairs of culvert head wall, approaches and aprons of culverts and drifts
4. Repairs of culvert drains / mitre drains / catch-water drains and excavation to original sizes
5. Cleaning of side drains and excavation to original size
6. Cleaning of mitre and catch-water drains and excavation to original size
7. Filling of potholes in carriageways
8. Repairs of shoulders and slope erosion
9. Light reshaping of carriageway (camber formation, corrugation, ruts and so on)
10. Maintenance of erosion controls in drains
11. Cutting of grass on shoulders and side drains
12. Bush clearing

Routine Maintenance Activities for Paved Roads

1. Inspection and removal of obstacles
2. Cleaning of drainage structures and their inlets and outlets
3. Repair of culvert head walls, approaches and aprons
4. Repair of culvert drains, mitre drains, catch-water drains and excavation to original size
5. Cleaning of side drains and excavation to original size
6. Cleaning of mitre drains and catch-water drains and excavation to original
7. Patch and reshape shoulder (gravel shoulder)
8. Patch surface edge
9. Patch potholes
10. Seal cracks
11. Sand off bleeding areas
12. Bush clearing and grass cutting

PERIODIC MAINTENANCE

These activities need to be carried out on a road after about 2 to 7 years depending on the traffic volume, pavement materials, rainfall, etc. This will be early determined by the Rehabilitation and Maintenance Planning System (**RAMPS**). They require extra resources to implement.

Below is a check lists for periodic maintenance activities for which separate work units or sub-programs could be established.

Periodic Maintenance Activities

1. Heavy reshaping of road or road section (by labour, drag or towed grader, motorized grader)
2. Installation or reconstruction of small drainage structures
3. Spot improvement of road or road section
4. Spot improvement of major structures (bridges, drifts)
5. Re-gravelling / resealing of road or road section
6. Provision of gravel stacks along the road to be used for routine maintenance activities.

EMERGENCY MAINTENANCE

These activities are required from time to time on a section of road whenever sudden and unforeseen damage occurs. Usually this requires additional resources.

By definition, emergency activities cannot be forecast during the annual maintenance needs assessment, so they cannot be planned. However, it is possible to reserve to a certain percentage of the routine maintenance funds for emergency case.

To plan realistically and organize the emergency activities when they happen it is necessary to identify the extent and kind of damage as fast and exactly as possible.

Emergency assessment is often left to the routine maintenance unit. As the supervisor, it is required to inspect the regularly and to inform the engineer immediately as emergency arises.

Emergency Maintenance Activities

1. Reconstruction or repair of damage to structures resulting from washouts, erosion, breakage or damage from high floods
2. Clearing of landslides, fallen tree or rock fall
3. Reconstruction or repair of damage to a road section resulting from washouts or erosion
4. Reconstruction or repair of damage to drainage systems resulting from serious silting up or erosion
5. Reconstruction or repair of damage to erosion protection resulting from serious washouts, landslide, etc.

The assessment should give sufficient to:

- estimate the input of resources (labour, material, equipment and tools)
- estimate the financial requirements
- development on an operation plan and organize the work immediately
- control and monitor the work.

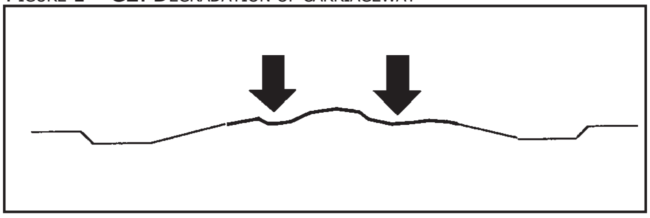
G2 DETERIORATION AND FAILURE OF ROADS

Road deterioration involves the worsening of roads over a period of time due to various causes. Deterioration leads to defects and subsequent failure of the road structure.

Deterioration of the carriageway (rutting, potholes, corrugations)

Ruts are the longitudinal depressions along the carriageway. They form on the wheel path commonly followed by the traffic. The narrower the carriageway, the more ruts will develop.

FIGURE 1 – G2: DEGRADATION OF CARRIAGEWAY



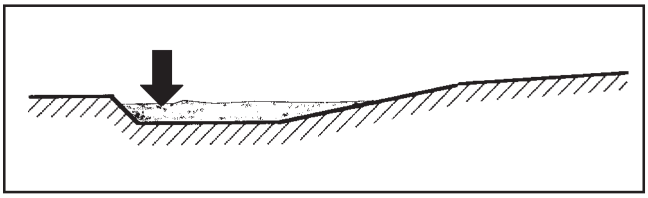
Potholes are depressions found randomly distributed over the carriageway. They occur on sections of the road where the road base has been exposed to high moisture levels. They are most formed by effect of traffic and water. Potholes cause driving over the carriageway to be bumpy and rather dangerous.

Corrugations are transverse wave patterns occurring on the carriageway formed mainly during the dry season on gravel or earth roads on which high proportions of loose material exists. carriageway. As the traffic passes, the loose material is pushed into regular lumps across the road.

Silting of the drainage system

Silt accumulates in the drainage channels or culverts leading to the malfunction of the drains or total blockage of the system.

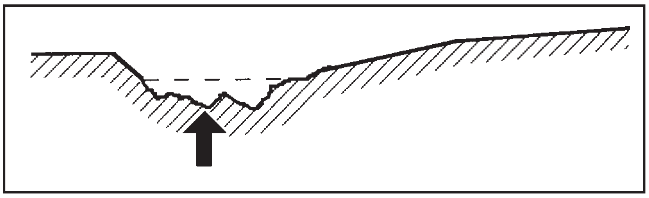
FIGURE 2 – G2: SILTING OF DRAINAGE SYSTEM



Erosion of the drainage system

This involves the loosening of exposed soil material (mainly in drainage channels or surface region) and their wash away by the erosive force or effect of water resulting to loss of useful material from the road.

FIGURE 3 – G2: EROSION OF DRAINAGE SYSTEM



CAUSES OF ROAD DETERIORATION

The main causes of damage to a road include the following:

Water

The damaging effect of water may arise in the following ways:

1. Stagnation of water in depressions (flat surfaces) on the road leading to infiltration into the lower (base) layers. As water infiltrates, it soaks and softens the gravel and base course, or the subgrade material causing the layers to fail by the punching effect of the traffic load.
2. Scouring or erosion of the steep sections of the road by running water.
3. In flat sections of road, runoff water in the drains will not be able to flow fast enough, resulting into settlement or deposition of silts in the drains, which normally build up to fill or block the drains.

Traffic

Traffic is the second main cause of road deterioration, and their damaging effect is as follows:

1. Traffic load causes deformation of the roadway. Vehicles often follow the same wheel tracks along the road. These repeated loading results into deformation (ruts) along the carriageway.
2. Material (gravel) loss through displacement by traffic. The higher the traffic the higher the rate of loss of gravel.
3. Over time, traffic causes closely spaced ridges (corrugations) to form across the width of the road called corrugations.

Gradients (very steep or very flat)

The steepness or flatness of the road section will accelerate the deterioration of the road by effects of water above. Flat terrain or road sections cause stagnation of water on the surface or in drains thus accelerating failure of road as explained above. Steep grades accelerate the erosion process.

Poor pavement construction

The poor construction resulting from poor workmanship, material, inadequate level of construction and poor supervision result in weakness in the road pavement structure or drainage structures which will accelerate their deterioration and failure.

Vegetation

In flat areas, tall grass in side drains slows the speed of running water enabling silt to settle and deposit in and eventually block the drain. Tall grass, trees and bushes obstruct drivers view resulting into accident hazards especially around corners.

CAUSES AND THEIR EFFECTS TO EARTH AND GRAVEL ROADS

TABLE 1 – G2:

Cause / Failure	Accidental Obstruction	Inadequate Construction	Drainage Erosion	Drainage Silting
Pavement Failure		1. Inadequate earth work over weak sub grade 2. No stabilisation on steep gradients 3. No sufficient camber		
Shoulder/ Carriageway Erosion	1. Embarkment failures, blocking of side drains	1. Gradients too steep with inadequate scour checks 2. No grass on shoulders or in base of side drains	1. Increase erosion channels in shoulders or base of side drains	1. Overflow of silted side drains.
Cross Carriageway Drainage Failure	1. Accidental blockages of culverts. 2. Accidental blockages of mitre drains	1. Inadequate culvert construction. 2. Accidental blockages of mitre drains.	1. Erosion of side drains leading to collapse of culvert head wall	1. Blocked culverts 2. Blocked mitre drains

G3 MAINTENANCE APPROACH

Road maintenance offers considerable scope for increasing efficiency by adopting different operational and organisational approaches. Some of these approaches include:

- Use of contractors
- Use of equipment
- Use of labour

In order to achieve the above-mentioned objectives, it is important to investigate alternative approaches to road maintenance which should be tested and introduced if they prove efficient and cost-effective.

CONTRACTING

It is difficult to provide work incentives particularly in road maintenance departments. As a result, work is often carried out inefficiently and both the quality and quantity of the outputs tend to be inadequate. One way of obtaining more efficiency is to make more use of private contractors. However, proper supervision is vital to all contract work. Specifications need to be developed and agreed upon and checks made to ensure that they are complied with.

It should be acknowledged that road maintenance works are to be implemented by contract (private sector) as a matter of Uganda Government Policy. However the private sector in Uganda has limited experience in carrying out road maintenance works.

This means that simplified administrative and contractual procedures need to be introduced. Moreover, that the executing ministries (the client) has to be able to prepare accurate work estimates and provide further essential backup services in the form of regular and timely inspections and payment. Finally, productivity data has to be assembled through work-studies in order to provide realistic unit rates for the maintenance activities. This has been addressed by the introduction and use of the standard for Contract Documentations and Procedures for Labour-Based Routine Maintenance (see **Volume 2 Manual B**).

EQUIPMENT INTENSIVE APPROACH

The use of heavy equipment is generally a big drain on scarce foreign exchange resources, since most machines, their spares and fuel have to be imported. In addition, the use of heavy equipment requires high initial capital investments.

Cases of under-utilisation of machines have been observed due to lack of even minor spare parts and high running costs. Moreover, due to the high initial investments, small-scale domestic contractors are thereby barred from carrying out works contracts which could be possible for them to manage if alternative approaches were allowed for.

USE OF LABOUR

Use of equipment for road maintenance has been proved in many instances in Uganda to be less cost effective compared to use of labour. Equipment is expensive, consumes fuel, lubricants and require spare parts which all have to be imported. Equipment also requires skilled operators, skilled mechanics and workshop facilities. If any of these items are not available, the equipment stands idle and road maintenance is not carried out.

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 lager range of maintenance activities, particularly when labour are well managed on a performance based payment system. However, labour based approaches demand intensive and good quality planning and supervision.

COMBINED USE OF EQUIPMENT AND LABOUR

In most cases, a combined use of labour and machines would provide the most appropriate solution. In certain areas, cheap labour may not be available at the time when roads need maintenance attention. Certain maintenance tasks can be carried out more effectively by machines while others are best carried out using labour. The most appropriate technology will therefore depend on the nature of activities best suited to labour and which are best carried out by equipment.

The choice between equipment and labour-based methods affects the basic organisation of road maintenance. Equipment based works favours a more centralised organisation, whereas labour-based solutions favours decentralised organisations.

The table below provides a brief overview of the viability of using equipment or labour for various maintenance activities.

TABLE 1 - G3: POTENTIAL WORK METHODS FOR ROAD MAINTENANCE

Activity	Potential Work Method	
	Equipment	Labour
Ditch cleaning and reshaping	Good	Good
Minor bridge and culvert repairs	Poor	Good
Building scour checks	Poor	Good
Repair of structure	Poor	Good
Grading unpaved surfaces	Good	Poor
Patching, sanding or local sealing of bituminous surfaces	Poor	Good
Filling of unpaved surfaces and slopes	Poor	Good
Grass cutting	Good	Good
Repair and replacing traffic signs	Poor	Good
Road line markings	Good	Fair
Stock piling gravelRegravelling	Good	Fair
Stock piling chippings	Good	Poor
Surface dressings	Good	Poor

ALTERNATIVE MAINTENANCE SYSTEMS

In recent years, a great deal has been learnt on the establishment of alternative road maintenance systems. The various solutions can be categorised as follows.

Alternative Systems to road maintenance:

- Force account system with employment as permanent or semi-permanent staff, supported by equipment (classical approach). (This system is largely in-efficient and in-effective in most cases as compared to contracting)
- Individual or collective maintenance responsibility for a road section
- Agreements between local communities and government
- Petty contracts for selected road maintenance activities
- Use of the private sector (contracting)

G4 MAINTENANCE MANAGEMENT

THE ROAD MAINTENANCE ORGANISATION

An ideal road maintenance system that make the optimum use of local resources would most likely comprise of several of the maintenance alternatives indicated in **Section G3**. Therefore, the key characteristics of the organisation would relate to the maximum extent possible to the local environment, involving local people in the planning and execution of maintenance work.

ORGANISATION STRUCTURE

In addition to the choice of maintenance approach or systems, also the type of maintenance operations and activities do influence the organisation and these operations whose needs are different from each other include:

- Routine maintenance
- Periodic maintenance
- Emergency maintenance

More detailed descriptions of these operations are provided in **Section G1** or later this section.

The maintenance organisation needs to cope up with the demands of each of these operations; have adequate capacity to carry out major maintenance operations (e.g. reshaping, regravelling, spot improvements, etc.) and have extra capacity to carry out suddenly appearing maintenance works (e.g. repair on structures, wash-outs, land slides, etc.). The extra capacity for urgent maintenance must be ensured at all times to avoid serious disruptions in access to the rural communities. Meanwhile for larger unforeseen defects, eventually additional resources must be made available by the programme management (i.e. major flood damages).

Periodic maintenance, such as regravelling and spot improvements, demands a special organisation which cannot normally be dealt with by the normal routine maintenance unit. For example, regravelling requires the same organisation structure and resources as the gravelling operation during the initial construction phase. Most organisations therefore prefer to establish separate periodic maintenance units from the continuous routine maintenance organisation.

The optimum maintenance approach for particular road would be determined by factors such as:

- Level of maintenance service required, which in turn depend on the function and purpose of the road
- The locals interested in the road
- The availability of local labour, equipment, finance and technical supervision
- The availability of competent contracting (private) firms.

MAINTENANCE MANAGEMENT UNIT

The Maintenance Management Unit would normally constitute the following:

- A **Road (maintenance) Engineer** in charge of all planning and supervision of all maintenance operations in given district or administrative area. The duties also include cost estimating and control, budget preparation, contract preparation and management, reporting and occasional field inspections
- **Supervisor of Works** responsible for programming and implementation of routine road maintenance and other maintenance operations. These tasks could also be combined with preparing and maintaining the road condition inventories
- **Road Inspectors** in charge of implementation of works at field level. These staff is directly responsible for instruction of workers, local contractors, work reporting and monitoring
- **Administrative support staff** in accounts staff (to process all payments, keep proper accounts, process budgetary allocations and exercise financial control), drivers, secretaries and office assistants

COMMUNITY INVOLVEMENT

The use of community self help is an issue which is often susceptible to simplistic solutions. An argument often heard is that rural roads are built specifically for the benefit of the people and they should therefore shoulder the responsibility for maintaining the road.

One has to remember that roads are built to carry vehicles. Many communities recognise the benefits that will come to their village from the access to markets, easier access to government services and better connection to the outside. Nevertheless, they do not necessarily recognise the individual benefit that will come to them. After all, most of them do not own a vehicle.

This is not to suggest that it is not possible to obtain community support for rural road maintenance. However, it is necessary to put a lot of effort into:

- Ensuring that the community fully understands the benefits that will come to them from maintaining the road
- Providing some form of incentive to the communities.

In the majority of cases, however further inputs in the form of regular cash wages will be necessary in order to establish a continuous and sustainable maintenance system.

Regular and sustained inputs can also be commercially negotiated with individuals, villages, village organisations (youth organisation, farmers associations, etc.) acting as contractors.

MAINTENANCE MANAGEMENT ACTIVITIES

Road maintenance operations require effective and careful planning, supervision and monitoring. The maintenance management cycle normally involves various steps and their logical sequence necessary for achieving an effective maintenance management system:

ROAD INVENTORY AND CONDITION SURVEY

Undertaking of road inventory assessment forms the basis for a road maintenance work planning, programming and subsequent reporting. The road inventory should list and describe all features of each individual road, the recorded data basis reference for all subsequent inspections and plans. The reader should understand the use of the standard format of Annual Inventory and Condition Surveys (**ADRICS**) of **Volume 1 Manual B**, for planning of district road maintenance in Uganda. The established system is comprised of three parts as:

- The District road inventory
- The District road condition inventory
- The Sub-county inventory

The complementary aspects of these include the traffic survey and computer aided data processing software system called **RAMPS**.

DISTRICT ROAD INVENTORY

The district road inventory can be a simple road map of the area showing all roads under maintenance. This map should provide information on:

- Road classification and category
- Surface types
- Major structures
- Average daily traffic
- Details of maintenance organisation (e.g. location of maintenance camps and division of responsibility)

ROAD CONDITION INVENTORY

The road condition inventory contains all the details of each individual road in the network and their conditions. The following items should be recorded with their current conditions:

- Geometry
  - alignment
  - profile
  - cross - section
- Pavement and sub grade Characters
  - soil conditions
  - ravel or other surface dressing condition
- Drainage
  - culverts
  - drifts
  - mitre drains
  - catch water and cut-off drains
- Structures
  - type
  - size
  - location
- Junctions
  - location
  - type of connection road
- Climate
  - rainfall
  - wind
- Traffic
  - annual average daily traffic
- Maintenance
  - details on routine maintenance (i.e. names of petty contractors)
  - maintenance works (e.g. data, location)

It is useful to supplement road inventories with simple drawings like **Strip Maps**. There must also be a road condition map of the district and sub-county network available in the office. Such diagram or maps are useful in the office preparing the operations plans. It helps the management to see at a glance the whole situation of a particular road.

ASSESSMENT OF MAINTENANCE REQUIREMENTS

It is necessary to carry out regular road condition surveys in order to asses the needs and plan maintenance works. These surveys form the basis for future work programmes and funding requirements.

District road condition surveys enable the road authority to:

- Be familiar with the road network and its maintenance problems
- Prepare objective and quantified assessments of the conditions of each road
- Get an objective impression of the effectiveness of the existing routine maintenance organisation
- Review periodic and other maintenance activities carried out since the previous inspection
- Determine routine and periodic maintenance to be carried out in the next construction season.

The district network is large and yet the resources and time available to maintain the roads is limited. It is necessary to assess the roads in an accurate time saving as possible. Hence, it is useful to concentrate on the identification and prioritisation of defects using a few well-defined key indicators for the road condition. Such indicators must be defined for each programme, depending on local conditions and requirements.

There are features which require special priorities set and include:

DRAINAGE

The drainage elements are the most important feature of any road. If this component of the road fails, serious damage will occur on the remaining parts of the road. Indicators for the drainage conditions are defined in the road section condition assessment - **look-up tables** of **Volume 1 Manual B** for district road planning in Uganda.

RUNNING SURFACE

The most important feature of the running surface is the cross-fall (or camber). The lack of cross-fall on the road carriage way will prevent rainwater from running off the road and lead to accelerated deterioration of that road surface. For the user of the road, the smoothness of the running surface is the most important feature. Earth and gravel roads require a continuous surface maintenance. The loss of gravel can be measured by digging small holes in the surface until the sub grade is reached. Measurements should be made at regular intervals along the road at the centre line, in the wheel ruts and at the road shoulders.

STRUCTURES

Inspections of the structures should not only be carried out to assess their general appearance. Thorough inspection implies checking all elements of a structure.

SETTING PRIORITIES

As a whole road maintenance is priority by its nature and the purpose it is undertaken for. However, the financial resources available are not sufficient to carry out all the maintenance activities identified during the road condition survey. It is therefore necessary to set priorities for what maintenance activities and which road sections are most important.

First priority is usually given to urgent maintenance activities (i) to ensure that the road network remains passable and basic access is provided and (ii) to limit the extent of damages exerted to a road section.

For each maintenance operation (routine, periodic and urgent) priority lists must be established. They may differ area to area according to the prevailing conditions. The following sections shows routine maintenance and periodic maintenance priorities. It is clear the most important routine maintenance activities throughout the year is to keep the drainage system in good running order.

Emergency maintenance works require immediate action. Priority should be given to those activities which make the road (even partially) passable.

PLANNING MAINTENANCE WORKS

For road maintenance, as for all other works activities, it is always advantageous to prepare a work plan. There are two major types of road maintenance plans, long term and short term plans.

The long plans that are important are general routine maintenance and the periodic maintenance plans. Long-term maintenance plans are established by the road authority. The road authority should know the current maintenance requirements and would know what resources are available over a longer period of time. Based on data from the road condition surveys, it is possible to forecast and plan the works according to the demand for maintenance and resources available.

Short-term plans are the operational plans which are prepared prior to the execution of any specific works carried out on a road section. The basis for these plans would normally be detailed inspection of the road condition, thereby ensuring that the assessment of work requirements are accurate, and that deviations from the work plan would be during implementation.

For routine maintenance works, short term planning may cover a period of say two to three months covering each individual road section for which a worker or group of workers has been assigned to. For periodic maintenance, which normally cover larger amounts of work, the road authority would prepare plans similar to construction and rehabilitation works, including bill of quantities, time charts and detailed specifications of work methods and quality standards.

IMPLEMENTATION

The quality standards to be achieved when maintaining roads are basically the same as for road construction works. Therefore, the maintenance staff must be aware of these standards and work methods used to achieve them.

WORK ACTIVITIES

ROUTINE MAINTENANCE

These are described in **Section G5**

PERIODIC MAINTENANCE

These are described in **Section G6** and **Section F**.

RESOURCES FOR MAINTENANCE WORKS

ROUTINE MAINTENANCE

Required tools for routine maintenance are described in **Section G5**. Other resources include labour and supervision vehicles.

PERIODIC MAINTENANCE

Refer to **Section G6** and **Section F**.

REPORTING AND MONITORING

The central objective of a maintenance reporting system is to provide programme management with an effective tool for monitoring work progress against the approved plan.

The reporting system will consist of several levels, starting at site level where the reports will contain the most detailed information. The following information should be provided in site reports:

- Description
- Chainage of road section
- Activities carried out
- Targets for each activity
- Task rates used
- Workdays spent on each activity
- Materials used

At district level, the report need to be detailed, consisting of a summary of the information gathered from all the sites. The district reports would normally contain the following information:

- Road names and numbers
- Total length of each road
- Total number of workers employed for each road
- Labour input for the maintenance of the main features (culverts, drains, carriage way, road reserve)
- Total workdays per kilometre

Periodic maintenance works would normally be reported using the same system and procedures as applied for construction works.

Reports on urgent maintenance would record:

- Description of road and location of site
- Date when work was executed
- Description of work and progress
- Workdays spent
- Materials used

Once this information has been checked and analysed, it should be used for (i) updating the road condition inventories and (ii) to improve and if necessary revise the general planning figures used by the road authority.

G.5 ROUTINE MAINTENANCE ACTIVITIES

Routine maintenance of low traffic rural roads is a widely dispersed activity, requiring small resources inputs over a large number of widely separated points. This activity is best suited for manual labour. The amount of work need to keep a length of road in good condition depends on several factors, such as type of road surface, traffic volume (number, type and size of vehicles),the severity of climatic road gradients to erosion, and the presence of bush and vegetation.

The activities we will discuss are as follows:

1. Inspection and removal of obstructions and debris
2. Clean culverts and their inlets and outlets
3. Clean/Repair drifts and their inlets and outlets
4. Repair culvert head walls and aprons
5. Clean side drains and excavate to original size
6. Repair / construct scour checks
7. Clean/Repair mitre drains and excavate to original size
8. Fill potholes and ruts in the carriageway
9. Repair shoulders and slopes erosion
10. Grub edges and reshape the carriageway
11. Cut grass
12. Clear bush

Please note that the description and break down of the activities discussed in this section is purely meant for you (the contractor) to understand **HOW** the activities are carried out. When it comes to the interpretation of the activities listed in the contract, the **SPECIFICATION** is the document to consult as it describes fully what you are required to cover under each activity.

The specification lists the routine maintenance activities as shown below:

- RM1 - Inspection and Removal of Obstructions
- RM2 - De-silting Culverts and Clearing Culvert Inlets and Outlets
- RM3 - Clear Side, Catch-Water and Mitre Drains
- RM4 - Repair Erosion of Shoulders and Drains
- RM5 - Repair Scour Checks
- RM6 - Grub Roadway
- RM7 - Clear Structures and their Waterways
- RM8 - Fill Potholes and Ruts in the Carriageway
- RM9 - Cut Grass and Bush
- RM10 - Other Activities as instructed

ROUTINE MAINTENANCE PRIORITIES

Critical elements of the drainage system, such as culverts and drains need particular attention and first priority should be given to the removal of obstacles which block the water passage away from the road. Small erosion channels must be repaired before the next rains can deepen and widen them. Both these tasks require regular inspection. Lowest priority should generally be given to those tasks which require significant inputs and produce limited results in terms of prolonging the life of the road (i.e. grass cutting and bush clearing).

The following table provides a list of priorities for routine maintenance to the following seasons:

TABLE 1 - G5: ROUTINE MAINTENANCE PRIORITIES

Season	Priority	Description
Before rains	1	• clean culverts and drifts
	2	• clean mitre drains
	3	• clean side drains
	4	• repair side drain erosion and scour checks
During rains	1	• inspect and remove obstacles
	2	• clean culvert and drifts
	3	• clean mitre drains
	4	• clean side drains
	5	• repair side drain erosion and
	6	• sour checks
End of rains	1	• repair erosion on shoulders, on slopes and in drains
	2	• reinstate scour checks
	3	• reshape carriage way
	4	• fill potholes and ruts in carriage way
	5	• cut grass
Dry season	1	• repair structures
	2	• reshape carriage
	3	• clear bush

ACTIVITY : INSPECTION AND REMOVAL OF OBSTRUCTIONS AND DEBRIS

DESCRIPTION/REMARKS

The activity includes an inspection of the complete length of the road. The inspection has to be carried out by the Supervisor on a daily basis. Any small obstructions can be removed immediately when detected by the Supervisor. The Supervisor is supposed to record any work that needs to be carried out immediately, e.g. blocked culverts during rainy seasons. He/she also records any larger emergency work that needs to be carried out and immediately informs the Contractor who in turn consults the Client.

WORK METHOD

- check the road on every working day for emergency maintenance requirements
- after every rainfall check whether inlets and outlets of all culverts and drifts are blocked
- after every rainfall check whether all side drains, mitre drains and catchment drains are blocked
- after every rain fall check whether obstructions on the carriageway are blocking the road
- if any obstructions or debris has to be removed along the section decide how many labourers are required to carry out the work
- organize the labourers and issue task rates.

REQUIRED HAND TOOLS

According to work required.

ACTIVITY : CLEAN CULVERTS INCLUDING INLETS AND OUTLETS

DESCRIPTION/REMARKS

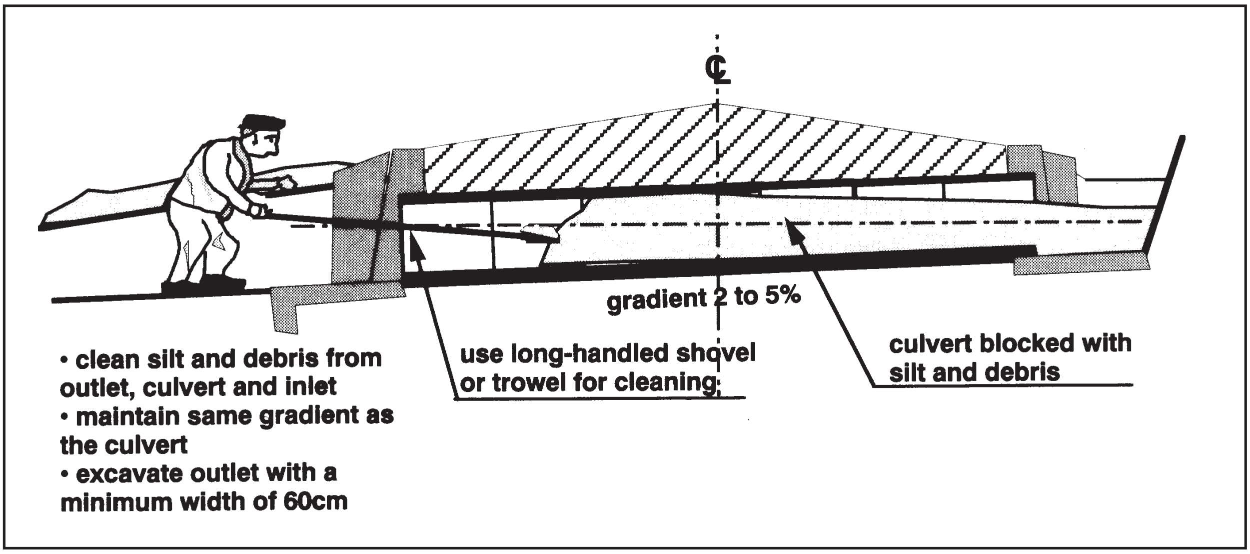
The activity includes the removal of all silt and debris from inside the culvert and the area of the head walls. The inlet and outlet ditches must also be cleared of vegetation, silt and debris. If the ditches are not silting or eroding, and they are to the current depth and profile, then the grass should be cut leaving the roots to bind the surface together.

If rainwater ponds in the culvert, inlet or outlet, the drains should be checked for the correct gradient. If the gradient is below 2% then the drain has to be set out again by the Supervisor using a line level, ranging rods and/or boning rods.

WORK METHOD

1. remove silt and debris from inlet, culvert and outlet. Set out outlet width and length using pegs and strings if necessary.
2. check gradient of the outlet if the culvert frequently silts up and re-establish outlet gradient if necessary
3. if gradient cannot be improved, inform the Engineer

FIGURE 1 - G5: REMOVING SILT AND DEBRIS FROM CULVET PIPE



REQUIRED HAND TOOLS

- Shovel
- Hoe
- Long handled shovel and trowel
- Measuring aids
- Line level, ranging rods and/or boning rods
- Pegs and strings

ACTIVITY : CLEAN/REPAIR DRIFTS INCLUDING INLETS AND OUTLETS

DESCRIPTION/REMARKS

Drifts are constructed instead of culverts where the natural gradient of the area does not allow the installation of culverts. Drifts are usually very delicate when it comes to establishing the minimum gradients. Accurate work is essential.

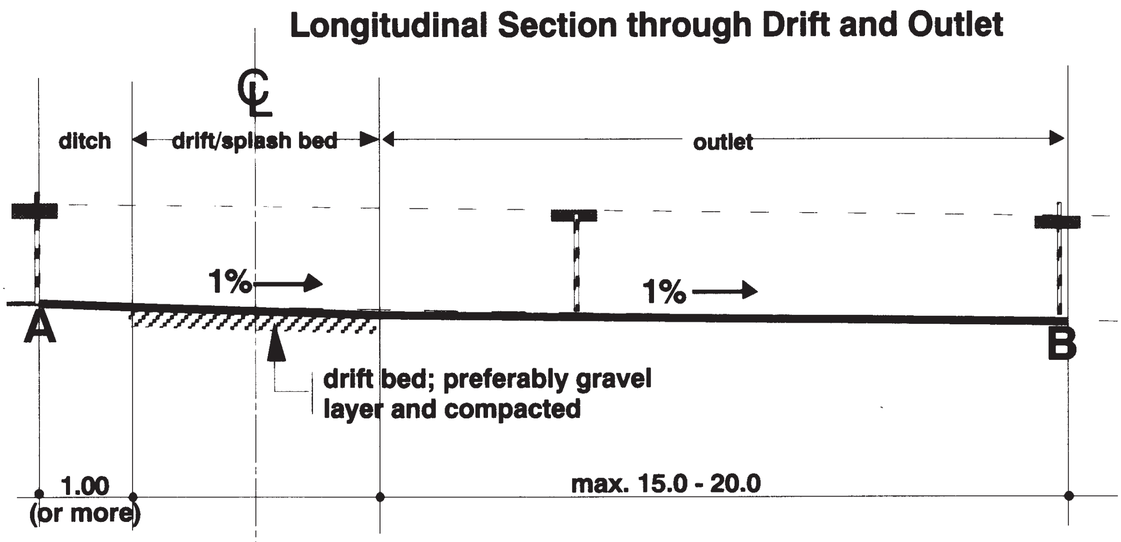
The activity includes checking the gradients and removing all silt and debris. The inlet and outlet drains must also be cleared of vegetation, silt and debris. If the drains are not silting or eroding, and they are to the current depth and profile, then the grass should be cut leaving the roots to bind the surface together.

If rainwater ponds in the drift bed, inlet or outlet, the drains should be checked for the correct and **uniform** gradient. If the gradient is 0% or not uniform, the drain has to be set out again by the Supervisor using a line level, ranging rods and/or boning rods.

WORK METHOD

1. check all levels in drift bed, inlet and outlet
2. establish correct level of drift bed

FIGURE 2 - G5: ESTABLISHING DRIFT LEVELS FOR MAINTENANCE



1. **Establish point A in the ditch at the lowest level of the drift/splash bed**
2. **Set point B (min. 1% gradient)**
3. **Check levels with traveller = uniform gradient (if the outlet is longer than 15 to 20 metres then the gradient can be reduced)**
4. **If the outlet cannot be established with a gradient of 1% then a smaller gradient can be accepted as long as the gradient is uniform and continuous along the entire drainage system**

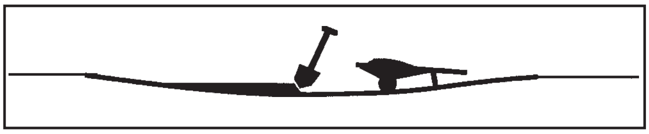
REMEMBER

the drift bed must never be lower than the end of the outlet

3. correction of wrong bed levels:
   - always check the levels of inlet and outlet first. If levels of inlet and outlet are correct, move to the next point.
   - reestablish the correct levels as described under steps 1 and 2
   - excavate/fill drift bed
   - provide drift bed with new gravel layer

4. remove silt from bed:
   - remove silt from drift bed down to the firm surface.
   - check levels again.
   - also check levels of outlets. If necessary correct outlets.
   - If the original surface under the silt is poor, follow the procedure as described under point 6

FIGURE 3 - G5: REMOVING SILT FROM DRIFT BED



5. repair erosion in bed:
   - remove poor material and excavate a uniform base
   - bring in good material (preferably gravel) in layers
   - compact layers of maximum 10 cm with earth rammer
   - establish smooth correct level with 1% gradient to the outlet

FIGURE 4 - G5: REPAIR OF EROSION

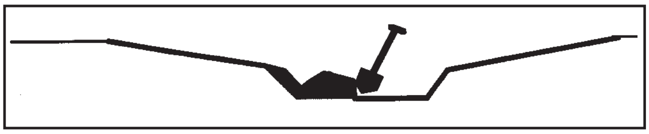
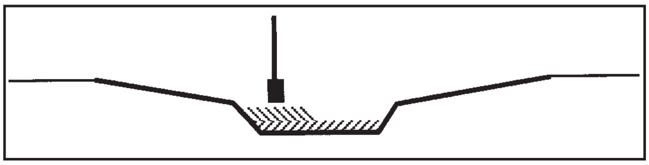


FIGURE 5 - G5: REPAIR OF EROSION - FILL AND COMPACT IN LAYERS



6. remove deformation and/or poor material from bed:
   - proceed in the same way as for erosion repair, point 5.

7. monitor the work progress, if necessary demonstrate how to carry out the work, check work standard and approve achieved tasks when the job is finished

REQUIRED HAND TOOLS

- Shovel
- Hoe
- Pickaxe
- 2 Wheelbarrows
- 1 Earth Rammer
- Measuring aids
- Line level, ranging rods and/or boning rods
- Pegs and strings

ACTIVITY : REPAIR CULVERT HEAD WALL AND WING WALLS

DESCRIPTION/REMARKS

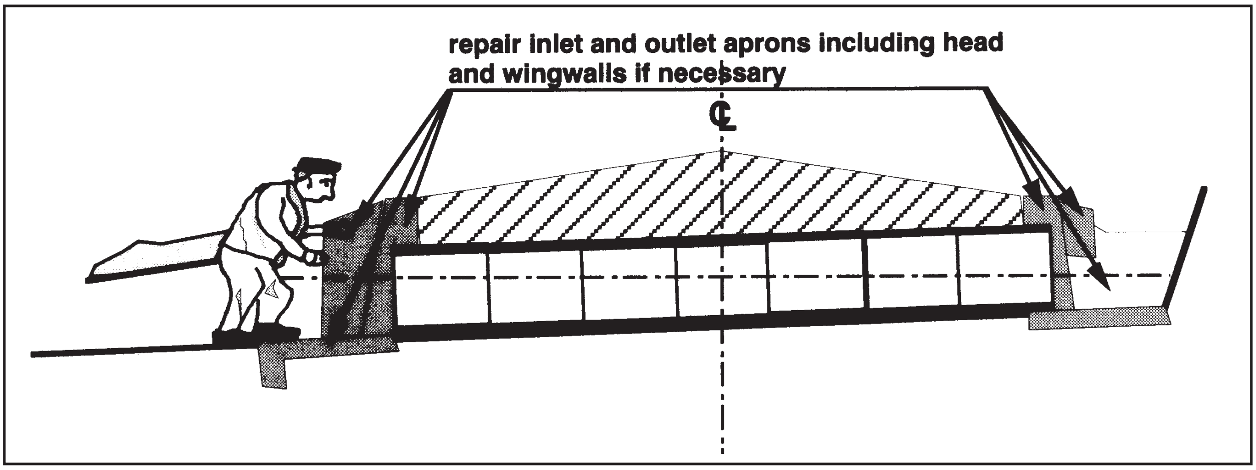
Many culverts have dry stone head walls, wing walls and aprons. Where these are damaged, it is necessary to repair them immediately with new stones or stones brought back into place. It is of advantage to have one labourer per gang who is specialized in this sort of work.

Repairing mortared masonry work and concrete work is not usually a routine maintenance activity. However, should this be included in a contract, then arranging for a qualified mason to carry out such repair work is necessary.

WORK METHOD

1. inspect head walls, wing walls and aprons regularly but especially after rain falls,
2. replace dislodged stones or fill in new ones. If necessary shape them to fit properly into the open gaps,
3. backfill where necessary with gravel or good quality soil.

FIGURE 6 - G5: REPAIR OF HEAD AND WING WALLS



REQUIRED HAND TOOLS

- Shovel
- Hoe
- Pickaxe
- Masons Hammer
- Masonry tools for mortared work
- Wheelbarrow

REQUIRED MATERIAL

- Additional Stones
- For mortared and concrete work: cement and sand, aggregate and water

ACTIVITY : CLEAN SIDE DRAINS AND EXCAVATION TO ORIGINAL SIZE

DESCRIPTION/REMARKS

Where the side drain is established to the correct depth and profile with a grass cover and no erosion, only grass cutting is required.

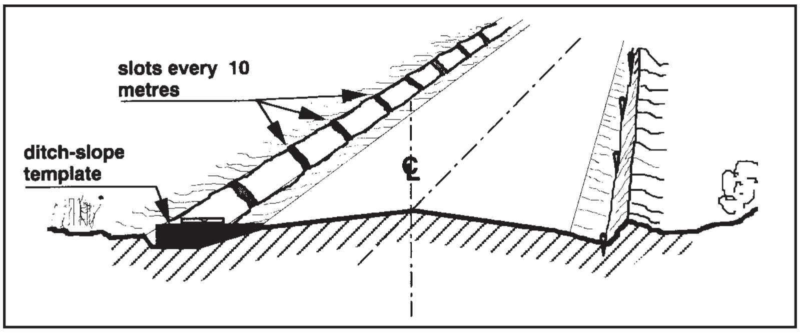
Where the drain has silted more than 10 cm in depth, the vegetation and silt must be removed to the correct depth and profile. This does not apply at the location of scour checks where silting is normal.

All debris and other material from the side drain must be removed well clear of the road and drainage system to prevent it being washed back. The material should never be used for any work on the existing carriage way.

WORK METHOD

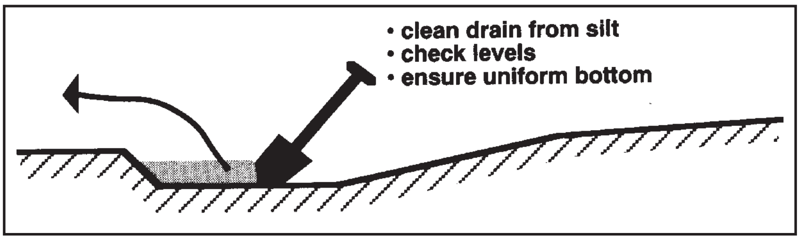
1. Using the ditch-slope template and a spirit level, a 50 cm wide slot is excavated to the correct drain profile every 10 metres. This acts as a guide for the labourers to excavate the drain and slope.

FIGURE 7 - G5: REPAIRS OF SIDE DRAINS - SETTING SLOTS



2. Remove all material from the side drain well clear of the road.
3. Recheck correct side drain levels and profile.

FIGURE 8 - G5: REPAIRS OF SIDE DRAINS - REMOVE SILT AND DEBRIS



REQUIRED HAND TOOLS

- Shovel
- Hoe
- Ditch-slope template and spirit level
- Pegs and strings

ACTIVITY : REPAIR/CONSTRUCT SCOUR CHECKS

DESCRIPTION/REMARKS

Where drain gradients are steeper than 5% the water flows at high speed. If no protective measures are taken, scouring is likely to occur on erodible soils. The simplest way of dealing with scouring is by reducing the volume of water (mitre drains at frequent intervals). In addition, replacement or new scour checks should be constructed to reduce the speed of the water. They hold back the silt carried by the water-flow and provide a series of stretches with gentle gradients interrupted by small "waterfalls"

WORK METHOD

1. Identify road sections where the gradient is more than 5% using a line-level and construct scour checks.
2. Identify exact ditch gradient and space scour checks according to gradient.
3. Cut pegs (min 50 cm long) and/or prepare stones.
4. Construct scour check with the correct profile. Use the scour check template for control.
5. Construct stone apron below scour check of min 40 cm length. Dig stones into the ground.

FIGURE 9 - G5: REPAIR OF SCOUR CHECKS

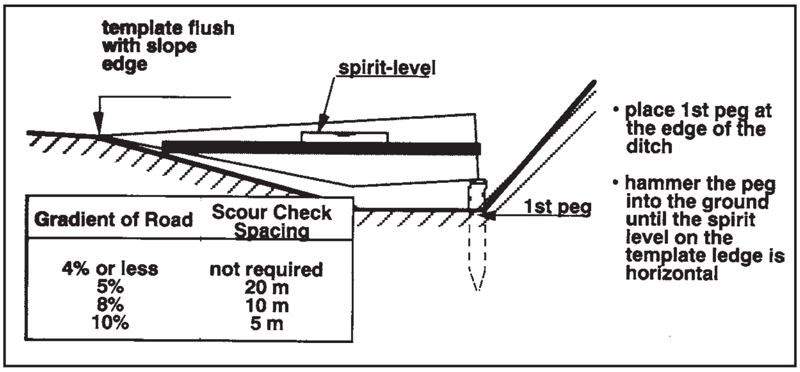
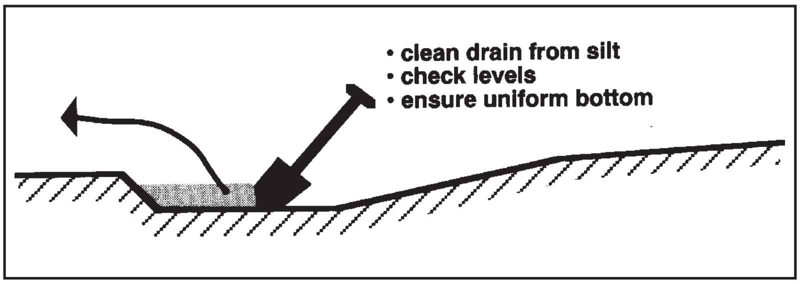


FIGURE 10 - G5: REPAIR OF SCOUR CHECKS



REQUIRED HAND TOOLS

- Template + Spirit level
- Sledge Hammer and Mason Hammer
- Cutlass and Shovel

ACTIVITY : CLEAN / REPAIR MITRE DRAINS AND EXCAVATE TO ORIGINAL SIZE

DESCRIPTION / REMARKS

The mitre drains have to be cleared of silt, vegetation and debris. If the mitre drains are silting, check the gradient and correct if necessary. Mitre drains should have a minimum gradient of 2%, but not less than the side drain.

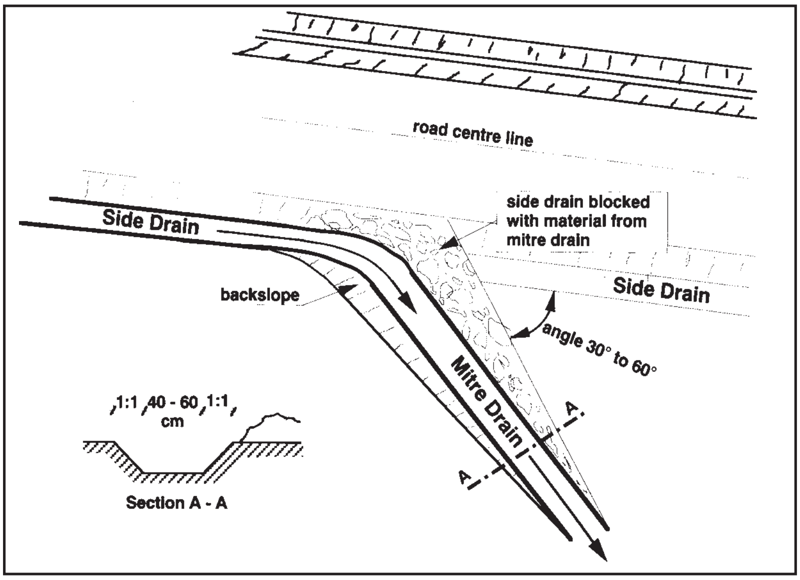
If the mitre drains are eroding, check gradient and correct as necessary or build scour checks in mitre drain or increase number of mitre drains to reduce the volume of water.

If the mitre drains are not silting or eroding, and they are to the correct depth and profile, then the grass should be cut leaving the roots to bind the surface together.

WORK METHOD

1. Identify mitre drains that have:-
   - silted
   - eroded
   - drained properly
2. Check correct gradient
3. Remove silt, vegetation and debris and dispose all material well off the drain
4. Shape the mitre drains according to the standard size (set out using pegs and strings)
5. Reinstate the side drain block

FIGURE 11 - G5: REPAIR OF MITRE DRAINS



6. Repair eroded mitre drains by installing scour checks or adding additional mitre drains to reduce the water volume.

REQUIRED HAND TOOLS

- Hoe and Shovel
- Strings and Pegs
- Ranging rods, boning rods and/or line level

ACTIVITY : PATCH GRAVEL SURFACE AND POTHOLES

DESCRIPTION/REMARKS

Patching gravel surface roads means to repair all surface defects such as potholes, gullies, ruts and soft spots to provide a smooth riding surface, improve road drainage and remove road surface traffic hazards.

All surface defects should be repaired as soon as possible, especially during wet weather, or traffic and water will quickly make them bigger.

A pothole is any depression with a depth of 5 cm or more.

Use only material that has been approved by the Engineer.

WORK METHOD

1. Drain out water

2. Remove weak or soaked material from pothole or rut and dig until firm ground/ material is reached

3. Fill in new material in layers of not more than 10 cm

4. Compact each layer using a hand rammer. Add some water if moisture content is too low.

5. Last layer to be slightly higher than the existing surface (allow for settling).

FIGURE 12 - G5: REPAIR OF PORTHOLES - REMOVE WEAK MATERIALS

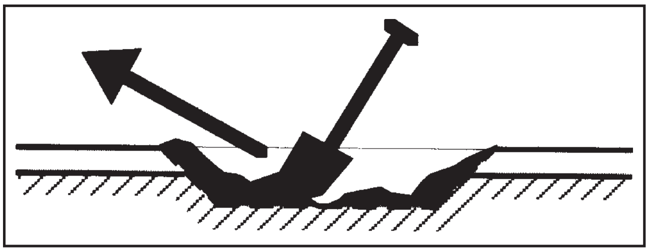


FIGURE 13 - G5: REPAIR OF POTHOLES - FILLING WITH GRAVEL

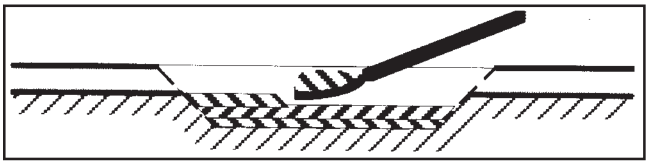


FIGURE 14 - G5: REPAIR OF POTHOLES - COMPACTING FILL MATERIAL

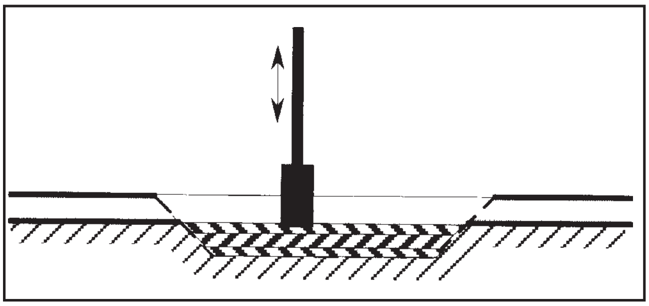
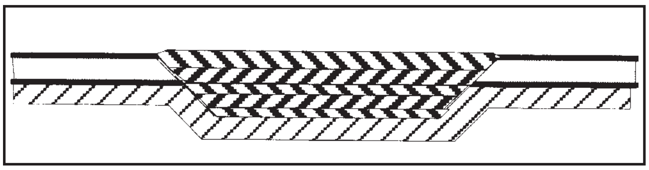


FIGURE 15 - G5: REPAIR OF POTHOLES - FINISHED SECTION



REQUIRED HAND TOOLS

- Pickaxe
- Hoe and Shovel
- Wheelbarrow
- Hand rammer
- Water containers

ACTIVITY : REPAIR SHOULDER AND SLOPE EROSION

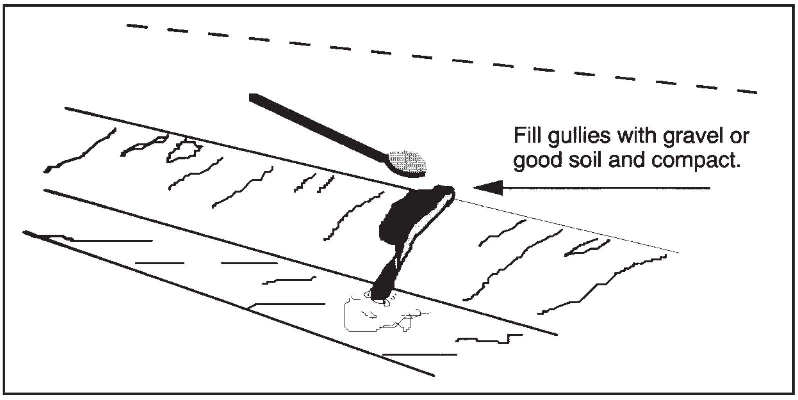
DESCRIPTION/REMARKS

Erosion gullies can be formed by water running over the edge of the carriageway and road shoulder. The gullies should be repaired and filled with gravel where available, or soil. Although no vegetation should be allowed on the carriageway, grass should be established on the sloping shoulders to resist erosion forces. Usually suitable grass may be found at the work site and replanted on the shoulders.

WORK METHOD

1. Fill gullies with gravel or good soil

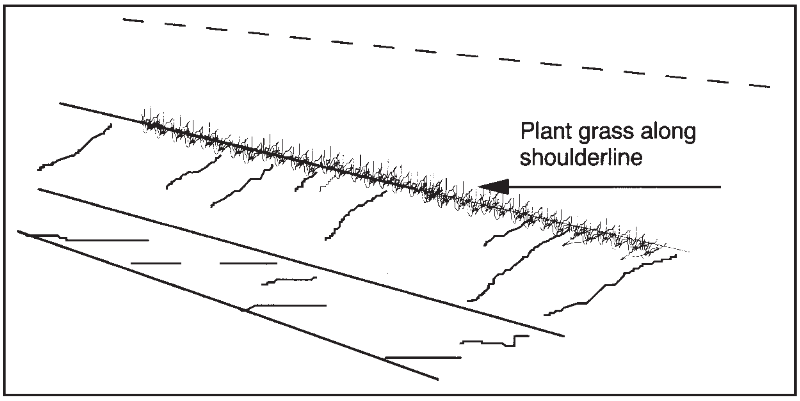
FIGURE 16 - G5: FILLING GULLIES



2. Compact the filled area with an earth rammer. Add some water if moisture content is too low.

3. Plant grass along shoulder.

FIGURE 17 - G5: PLANTING GRASS



REQUIRED HAND TOOLS

- Hoe and Shovel
- Rake
- Wheelbarrow
- Hand rammer
- Water Container

ACTIVITY : GRUB EDGE AND RESHAPE CARRIAGEWAY

DESCRIPTION/REMARKS

Grass growing on the edge of the carriageway can prevent rainwater causing erosion on the shoulder, but on the other hand it may also grow into the carriageway and hinder rainwater from draining easily.

This activity is sometimes referred to as weeding. The edge of the carriageway should be grubbed only up to the shoulder break point as far as district feeder roads are concerned. With some classified roads it may also be appropriate to grub the entire side slope down to the invert level.

The grass roots should be removed from the carriageway. A stringline should be set out at the edge of the carriageway (begin of shoulder) as a guideline for the activity. Debris should be removed well clear of the road and the drainage system.

In time the camber of the carriageway is reduced due to the action of traffic and weather. The camber should be reshaped by bringing back material from the edge towards the centre line. A camber board or a straight edge should be used to control the uniformity and gradient of the reshaped carriageway area.

WORK METHOD

1. Set out shoulder-carriageway line using pegs and strings.

2. Grub edge using a hoe towards the slope and remove the material (grass and roots) well away from the road and the drains.

3. Cut shoulders and/or road edges back to original shape.

4. Fill material into ruts by using rakes or shovels.

5. Check camber using a camber board or a straight edge.

REQUIRED HAND TOOLS

- Hoe and Shovel
- Rake
- Camber board or straight edge with spirit level

FIGURE 18 - G5: GRUBING

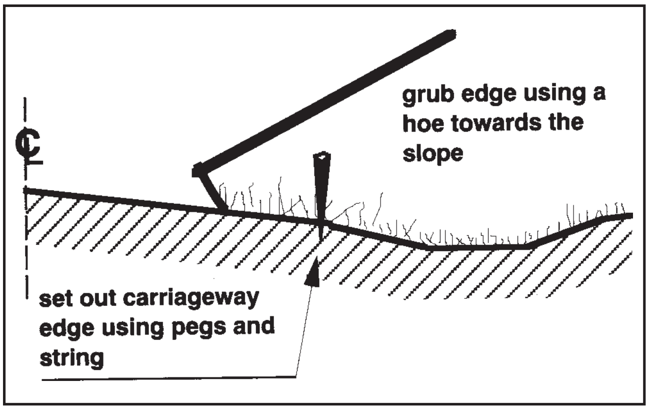


FIGURE 19 - G5: REPAIR OF RUTS

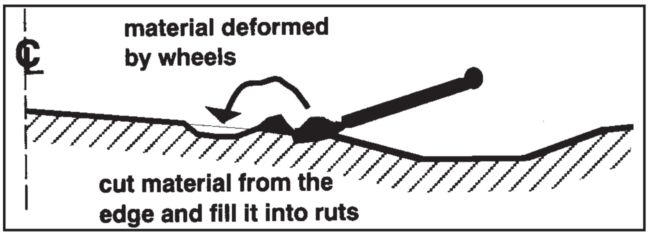


FIGURE 20 - G5: REPAIR OF RUTS

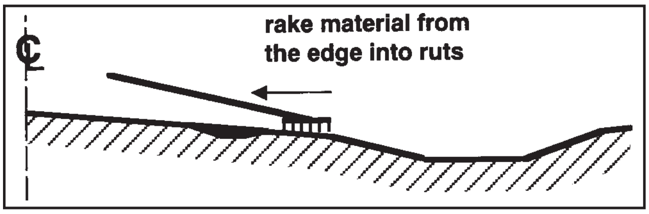
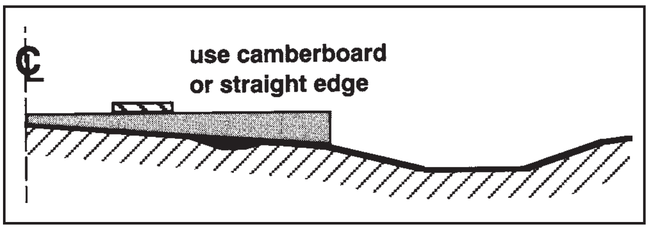


FIGURE 21 - G5: CHECK REPAIRED LEVELS



Road Maintenance G
Routine Maintenance 5

ACTIVITY : CUT GRASS

DESCRIPTION/REMARKS

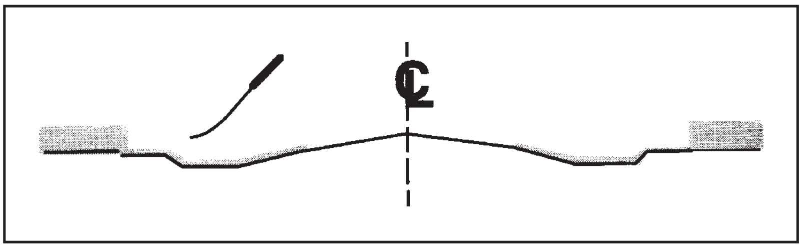
Grass cutting on the shoulders and in side drains, turnout/mitre-drains and culvert outlets and inlets permits the easy flow of water away from the road area and also improves visibility for traffic safety.

Grass roots in the drainage system bind the soil together and also reduce the speed of flow of water and so diminish erosion and scouring in hilly areas.

Long uncut grass will slow water flow in flat areas and help cause silting.

WORK METHOD

FIGURE 22 - G5: CUTTING GRASS



1. Place safety signs.
2. Cut all grass and other vegetation from the shoulders, side drains, mitre drains and culvert inlet and outlet channels, to maximum height of 10 cm.
3. The grass should be cut to a width of 3 m measured from the road shoulder break point or 1.5 m each side of the center-line of culvert inlet or outlet or mitre drain.
4. Remove grass cuttings immediately from both the roadway and other cut areas and deposit/spread at least 1 m clear of the outside edge of the drain.
5. Remove safety warning signs.

REQUIRED HAND TOOLS

- Grass cutters/slashers
- Rake

ACTIVITY : CLEAR BUSH

DESCRIPTION/REMARKS

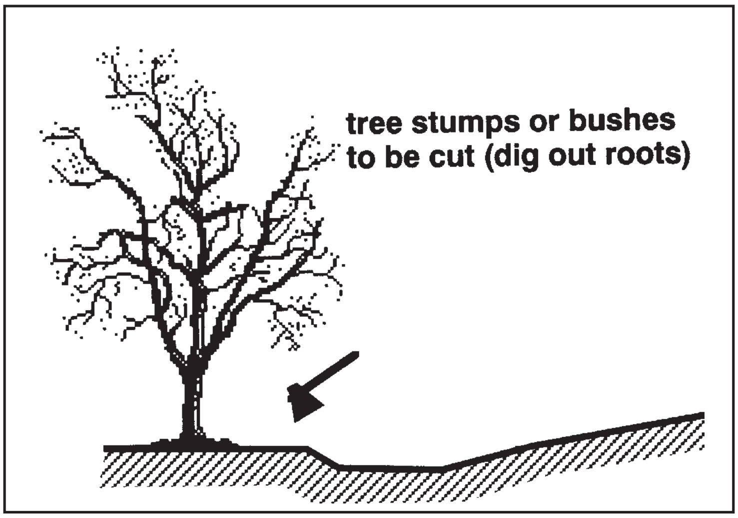
Trees and bushes are cleared to provide good visibility for traffic safety.

All bushes and branches hanging over the road, shoulders, side drains, mitre drains and traffic signs should be cut down and disposed out of the road. The debris should be burnt if there is no risk to traffic or surrounding crops/vegetation. Otherwise, it should be removed well behind the side drain.

WORK METHOD

1. Cut trees and bushes from the roadside and drains to a maximum height of 10 cm from ground level.
2. Cut all trees and bushes within a width of 3 m measured from the road shoulder break point on both sides of the road, or as directed by the Engineer.
3. Remove all cut trees, bushes and grass cuttings from the road and adjacent areas and spread/deposit on a location at least 1 m clear of the outside edge of the drain.

FIGURE 23 - G5: TREE AND STAMP REMOVAL



REQUIRED HAND TOOLS

- Cutlass
- Axe
- Rake

Road Maintenance G
Routine Maintenance 5

ROUTINE MAINTENANCE PRODUCTIVITY NORMS

TABLE 2 - G5: PRODUCTIVITY STANDARDS FOR ROUTINE MAINTENANCE

ACTIVITY		UNIT	TASK DIFFICULTY 1	2	3	4	NOTES
CLEAN CULVETS AND INLETS		as shown	4 culverts per day	1 culvert per day	2 days per culver	4 days per culvert	Difficulty = Silt depth - 1. Up to 25%. - 3. 50% to 75% - 2. 25% to 50% - 4. Over 75% Tasks are for 600 dia. Culverts with 7 rings
CLEAN CULVERT OUTFALLS		m/day	55	40	25		Difficulty = Silt depth - 1. Up to10cm - 3. Over 20cm - 2. 10 to 20cm
REPAIR CULVERT HEADWALLS		No./day	7	4			Difficulty = Type of repair - 1. Minor repair - 2. Major repair
CLEAN MITRE DRAINS		m/day	60	45	30		Difficulty = Silt depth - 1. Up to10cm - 3. Over 15cm - 2. 10 to 15cm
CLEAN SIDE DRAINS		m/day	Wet areas 65 Dry sof t soil 55 Dry hard soil	45 40 23	30 30 18		Difficulty = Silt depth - 1. Up to10cm - 3. Over 15cm - 2. 10 to 15cm
REPAIR SCOUR CHECKS		No./day	5	7			Difficulty = Type of scour check - 1. Wood - 2. Stone
REPAIR SIDE DRAIN EROSION		m/day	Wet areas 100 Dry areas 100	80 50	60 23		Difficulty = Depth of erosion - 1. Up to15cm - 3. Over 30cm - 2. 15 to 30cm
REPAIR SHOULDER EROSION		m/day	100	80	65		Difficulty = Depth of erosion - 1. Up to 10cm - 3. Over 15cm - 2. 10 to 15cm
GRASS PLANTING		m/day	100	80	65		Difficulty = Planting width - 1. Up to 0.5m - 3. Over 1m - 2. 0.5 to 1m
FILL POTHOLES IN CARRAGEWAY		wheel barrows / day	25	18	13	8	Difficulty = Hauling distance - 1. No haul - 3. 100 to 200m - 2. Up to 100m - 4. Over 200m
FILL RUTS IN CARRAGEWAY		m/day	Wet areas 70 Dry areas 50	50 30	35 15	15 7	Difficulty = Hauling distance - 1. No haul - 3. 100 to 200m - 2. Up to 100m - 4. Over 200m
GRUB EDGE OF CARRAGEWAY		m/day	Wet areas 270 Dry areas 190	200 120	130 70		Difficulty = Grubbing width - 1. Up to 0.5m - 3. Over 1m - 2. 0.5 to 1m
RESHAPE CARRAGEWAY *		m/day	70	50			Difficulty = Type of reshaping - 1. Light (Up to 75mm) - 2. Heavy (Over 75mm)
GRASS CUTTING	LIGHT	m/day	Wet areas 425 Dry areas 310	260 230	190 170		Difficulty = Width of cutting - 1. Up to 1m - 3. Over 2m - 2. 1 to 2m
	DENSE	m/day	310	240	175		
BUSH CLEARING	LIGHT	m/day	425	260	190		Difficulty = Width of bush - 1. Up to 1m - 3. Over 2m - 2. 1 to 2m
	DENSE	m/day	275	225	175		

Note: * All tasks except Reshaping are measured along one side of the road only.

G6 PERIODIC MAINTENANCE

Periodic road maintenance activities are required to be carried out on a road after periods depending on the rate of deterioration under traffic and environmental conditions such as rainfall. The level and number of cycles of periodic maintenance interventions may be determined from the District Road Rehabilitation and Maintenance Planning System (**RAMPS**).

Periodic maintenance activities may involve one or more of the following:

1. Heavy reshaping of road or road section (by labour, drag or towed grader, motorized grader)
2. Installation or major reconstruction of small drainage structures.
3. Spot improvement of road or road section.
4. Spot improvement of major structures (bridges, drifts).
5. Re-gravelling / resealing of road or road section.
6. Provision of gravel stacks along the road to be used for routine maintenance activities.

Such works could be organised the same way as rehabilitation and new construction works under a contract works carried out by small-scale private contractors (with a limited amount of equipment) or force account.

Depending on the magnitude of the road deterioration, periodic maintenance works would require the same type of resources as prescribed for rehabilitation or construction works. Tasks and resources required for these works therefore would be assessed, estimated, calculated, planned and deployed in the same way as road rehabilitation or construction works (**Section D4** of this Manual).

TABLE 1 - G4: PERIODIC MAINTENANCE PIORITY

Priority	Description
1	• rehabilitation • installation of new culvets • reconstruction of existing culverts at new levels
2	• providing gravel stacks for use in routine maintenance
3	• rehabilitation of road section • heavy reshaping by dragging, brushing or grading
4	• reshaping of road to regravelling • regravelling / sealing of entire road • spot improvement

Section H

Site Management

Section H
Site Management

Section H1

Site Establishment and Preparation Works

Section H1
Site Establishment and Preparation Works

SITE MANAGEMENT

H1 SITE ESTABLISHEMENT & PREPARATION WORKS

General

Establishing a site involves setting up a new site and undertaking preparation works in the area of the construction project. In the case of direct labour works (force account) it is the responsibility of the project engineer. In the case of a contract, it is the responsibility of the contractor and his/her staff.

After procurement has been finalised the Engineer or the contractor's staffs then identify all the necessary requirements for the works. These include the following:

- Tools and equipment
- Plant with the dates when they are required
- Storage facilities required for site
- Staff requirements with dates
- Labour recruitment with dates
- Construction materials
- Administrative forms and stationary required

H1.1 SITE CAMP

Before any works commence, the camp must be established. The site camp is where the project site staff live, and materials, tools and equipment are kept. The size of a site camp depends on the size and complexity of the project but typically consists of the following:

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.

Store: Will be required for the storage of tools and materials. All stores must be stacked neatly so that they can be easily counted, located or collected. Stores also need to be carefully stacked 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 and large tools may be stored outside but within the camp enclosure.

Workshop: Equipment and tools workshop may be required for repairs and servicing.

Staff Accommodation: There must be accommodation for the site permanent staff. This may consist a single room for each foreperson. Where there are nearby villages site support labourers should preferably come from home.

Access and Fencing: A site fence is an important aspect of security that must 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 location of the camp should be decided by the Engineer or by the contractor and should preferably be near the site activities. Care should be taken to locate or build a site camp which is efficient, secure, and pleasant to live in. In labour based works it is preferable to relocate the site when distance from the work front exceeds 5 km to avoid delays in tools, equipment, staff and materials movement. If the distance exceeds 5 km, then satelite camps may be required. The site camp should be near the source of safe water and be accessible to vehicles.

The site camp will typically be constructed of huts to house the staff, store, toilets and bathroom. Huts can be made of corrugated steel sheet on timber panel and in such a manner that can be moveable from site to site. Huts can also be made from readily available local materials. However in the case where the site camp is located in highly built areas, such accommodation required for site camp can be rented.

H1.2 HAND TOOLS

Types of tools required for labour based road works are provided in the list below. The type and number of tools required depend on the activity, task given, method of work and the size of the project. Allocation of tools to labour have already been described for each activity in **Sections E** and **F** of this manual. The foreperson is responsible for the safe keeping of tools and will be assisted in doing this work by a stores clerk. Tools will be issued and collected from labourers daily until after a suitable period that the labourer may be entrusted. This should be to the discretion of the foreperson who will be responsible for recovery of any lost tools.

It is important to realize that the efficiency of the hand tools depends on quality and condition. It is therefore important to select and maintain your tools properly. Tools need to be maintained by repairs, cleaning, replacement of parts and sharpening as appropriate. Where replacement of parts or handles is needed, the stores clerk needs to ensure that such replacement parts are always available in the store. A casual labourer may be assigned to carry out such repairs or maintenance works. Any worn out tools need to be collected and disposed off from time to time by selling to recover residual value.

TABLE 1 - H1: HAND TOOLS

Item	Tool / Implement Description	Item	Tool / Implement Description
1	2 m straight edge	26	Panga (18") (Bush knife)
2	3 mm dia. nylon rope 200 m	27	Pickaxe 7lb
3	5 lb hammer	28	Plumb bobs
4	Anvil (30 kg)	29	Profile boards
5	Axes (short handle)	30	Ranging rods
6	Boning rod set	31	Ripping saw
7	Bow saw 26"	32	Safety goggles
8	Camber template	33	Shovel, round nose
9	Claw hammer 1.5 lb	34	Slasher grass
10	Crow bar, chisel and point	35	Sledge hammer 14 lb
11	Ditch template	36	Slope and camber template
12	Earth rammer 14 lb	37	Spare axe handle
13	First Aid kit	38	Spare Handle Hoes
14	Flat file 12" second cut	39	Spare Handle Matocks
15	Gloves	40	Spare Handle Pick axes
16	Gumboots	41	Spirit level (4 foot)
17	Heavy duty rake, 14 prong	42	Square
18	Jembe (hoe) 3.5 lb	43	Square mouthed shovels
19	Jerricans	44	Steel floats
20	Lamp	45	Tape measure 30 m
21	Line level	46	Tape measure 5 m
22	Mason's trowel	47	Water drum (200 litres) (Plastic)
23	Mattock 4.5 lb	48	Watering can
24	Mortar pans	49	Wheelbarrows
25	Overalls	50	Wooden floats

H1.3 EQUIPMENT

Although the use of labour based methods is emphasized here, equipment in road works is necessary for supervision transport, materials transport, gravel haulage, watering and compaction.

Owing to the importance of this equipment, it is vital that their management and maintenance is both effective and efficient. It may therefore be important to set up an equipment repair and maintenance system that will satisfy the programme requirements.

The problems associated with the use of plant and equipment relate to insufficient planning, management and support.

The following principles should be applied to the management of transport and equipment.

The plant and vehicles should be acquired, operated and supported so that:

- Only basic, robust and reliable equipment is procured and have a prospect of a long and profitable life, ease maintenance, easy access to cheap spare parts, appropriate design and construction for the conditions and flexibility of use for different tasks. Where possible consider hiring equipment that will only be required intermittently.
- Equipment is available to a degree that will not disrupt planned road improvement and maintenance activities nor their organization and supervision.
- Equipment will have a minimum breakdowns.
- Equipment operates in an efficient manner.
- Equipment achieves a satisfactory and cost effective working life.

Taking due account of the nature of district roads departments or local contractors, logistics, and the capabilities of equipment maintenance in the districts or with most contractors and on site, a target level of equipment fleet availability of 70% is recommended. This is calculated from days available for work divided by total working days, for each equipment item, and averaged for the whole fleet. Such a level of availability should be achievable without undue cost and should not cause significant disruption to the works and supervision.

Equipment Operations – Planning and Reporting

Equipment, the spare parts and consumables are expensive and therefore their use require total control. A planning and reporting system is necessary to provide information on the use of equipment, the mechanical work carried out, the use of spare parts and consumables. For each piece of equipment or vehicle you need know:

- Operating cost over a certain time
- Availability and utilization
- Fuel consumption
- Spare part consumption
- The present condition

The above information can be done by having a separate log-book for each equipment or vehicle on which the following details can be recorded:

- Date
- Working site or journey details
- Odometer or hour-meter at the beginning and the end of each day, plus distance or time driven
- Fuel and oil issued
- Signature of driver

Typical operations and maintenance log-books are shown below:

TABLE 2 - H1: TYPICAL OPERATIONS LOG-BOOKS

Date	Details of journey	Km / Hr before	Km / Hr after	Total Km / Hr this journey	Fuel issued	Signature of driver

TABLE 3 - H1: TYPICAL MAINTENANCE LOG BOOK

Date	Details of repair / service	Spare parts used	Consumable items used	Signature of mechanic	Next service due

Equipment Maintenance Strategy

There must be a "**Planned Preventive Maintenance**" approach to equipment maintenance rather than "**Wait until it breaks down**". The "wait until it breaks down" situation is expensive in long term as the equipment rapidly become unreliable with increasing frequency and cost of breakdowns. The equipment will also not last its expected lifetime. This later case is also not recommended by the manufacturers.

"Planned preventative maintenance" – is the strategy recommended by manufacturers and used by responsible owners to minimise costs and maximise availability and usage. In this maintenance strategy regular maintenance is carried out to minimise the risk of failure of equipment during operation. The equipment maintenance is planned in advance in conjunction with roadwork operations.

Planned maintenance is not a specific type of equipment servicing but the application of maintenance in a systematic manner. It is the comprehensive planning of the maintenance function through a programme of service schedules designed for each item of equipment.

To implement the maintenance strategy there must be:

- an inventory of all plant and equipment to be maintained. (Equipment Record Cards, etc.)
- a complete schedule of all the individual tasks that must be carried out on each item of plant in accordance with the manufacturers or local agents recommendations.
- a programme of events indicating when each task must be carried out. (Maintenance Programme Chart and Weekly Schedule).
- a method of ensuring that the work listed in the programme is carried out. (Job Cards, etc.)
- a method of recording the cost and results and assessing the effectiveness of the programme.

Planned Maintenance System (PMS)

An example of a preventative maintenance schedule is provided in **Table 4-H1**. Service types A, B and C will normally have increasing range of checks and items of work.

For time based services the timing of each service for each item of equipment will be planned in advance, to the week, for the coming year or contract period on the maintenance programme chart. This chart is prepared by the mechanic or supervisor responsible for the equipment maintenance.

TABLE 4 - H1: PREVENTATIVE MAINTENANCE SCHEDULE

Item	Period Between Service Types		
	Service A	Service B	Service C
Tractors	1 Month	3 Months	6 Months
Trucks	3,500 km	10,500 km	21,000 km
Pickup	4,000 km	12,000 km	24,000 km
Motorcycles	1 Month	3 Months	6 Months

On a weekly basis, the equipment owner / manager and the mechanical supervisor should plan the daily service and repair for the following week. Forepersons and operators responsible for each item of equipment can be notified of the exact day on which the item is required in the workshop with adequate notice.

With this procedure everything can be prepared for the workshop visit including any spares, consumables, materials and tool requirements.

For each type of service (A, B or C) and equipment model, a **PMS** schedule should list every job item and description that must be carried out based on the manufacturers service handbooks.

H1.4 RECRUITMENT AND REDUNDANCY

Recruitment

Recruitment is simply the process of filling a vacancy. It involves the examination of the requirements for filling the vacancy, consideration of the sources of suitable candidates, drafting job advertisements and selecting suitable media to carry them, assessing appropriate salary levels for new employees, and arranging interviews and other aspects of selection. Selection requires the assessment of candidates by various means and the choice of successful candidates.

There are a number of ways of analyzing the target workers qualities but the basic one's are:

- Ability to do the job
- Willingness to do the job
- Manageability when doing the job

Recruitment of Contract Labour

The recruitment of unskilled workers should be carried out openly preferably in a public meeting a week or two before commencement of actual site works.

For contract work the contractor is responsible for recruiting his workers assisted by local leaders and stakeholders. A representative of the District Engineer should attend the recruitment meeting to ensure that correct procedures are followed.

The following procedures should be followed to ensure good dissemination of information about recruitment and actual recruitment:

1. Announcement of labour requirements and recruitment meeting including relevant location to be made in good time with specific encouragement to women (preferably two weeks in advance). The meeting location should be close to the site.
2. A standard notice of recruitment should be filled in and handed out to the Local Administrative, local political leaders, women groups leaders, other local group leaders, church leaders and youth leaders among others.
3. Standard notices should be posted in public places such as schools, markets, trading centres.
4. In all cases, it must be stressed that both men and women are equally eligible for employment. Efforts should be made to involve female representatives during the recruitment process e.g. LC1 and LC II women secretaries and councillors.
5. At the recruitment meeting the contractor or the district engineer's representative should clearly explain the following:
   - Nature and type of work for which recruitment is being sought.
   - Anticipated employment duration
   - Number of labourers to be recruited
   - Terms of employment
   - Wage rates, timing and arrangements for payment in case of contractor defaults on payment of his workers.

- Contractors obligations e.g. Provision of shelters for breast feeding women, provision of separate sanitary facilities for women and men, etc.
- Women and men are equally eligible for work and will be paid at equal rates for their tasks.
- In case a situation of more job seekers than available vacancies arises, then the secret ballot system should be used to avoid possible accusations of favouritism or corruption.

6. Discussions will follow as a reaction from those attending the meeting and clarification to issues raised by the contractor or the District Engineer's representative.
7. The jobseekers are then invited to forward and form orderly queues.
8. In all cases the quota system of 50% shall be applied in the recruitment to allow for a ratio of 1:1 for men and women.
9. If this quota system ratio does not apply, and that there is a minimum requirement to be achieved for special interest group, then an affirmative action in line with relevant national policies be applied provided such a policy is acceptable and fair. Care should be taken when implementing such a policy so that it does not impose a maximum limit on the participation of such groups.

It's an infringement on human rights to discriminate against women in:

- Selection procedures
- Terms on which employment is offered
- Access to opportunities for training or promotion
- Fringe benefits
- Deciding on which workers shall be made redundant.

When a recruitment meeting fails to obtain the required number of labourers it may usually due to insufficient effort made during mobilization and sensitization drives.

The recruits should sign completed Casual Employment Forms and will be given a copy of the form for their information and to bring on payment days to verify their identity. The recruits should be advised on which days they will report for work. (Not all will be required on the first day).

The secret ballot system to be used in case of excess job seekers than available vacancies shall follow the procedure below:

- Every applicants name is registered and they are given a provisional employment number.
- A separate piece of paper will be marked for each provisional employment number, folded and placed in a suitable container or box.
- A responsible person will randomly select the folded papers one at a time from the container without observing the numbers.
- This will be repeated until the required number of recruits is achieved.
- The number on the selected paper will be read out and the person will be registered in turn and asked to sign the casual employment form.

Where possible a register of reserve applicants should be made in case of further recruits are required due to absentees or desertions as site work continues.

Redundancy

Redundancy simply means that the organization or firm's need for employees to do the work of a particular kind has ceased or diminished, so that someone has to lose their job.

The criteria used to select individuals for redundancy must be fair and reasonable.

Wrongful as opposed to unfair dismissal occurs when insufficient notice is given. It may give rise to civil action for damages equivalent to the actual loss incurred. Wrongful dismissal may be claimed by a worker regardless of the length of service with the organization.

Disciplinary procedures should be made in writing easy to understand and made known to employees and their representatives.

Employers should be able to forecast their human resource needs in advance such that workers have good notice of when they are likely to be declared redundant such that they can seek other alternative sources of income and controlled expenditures in advance to ensure continued welfare of their homesteads. Cases where workers are not given adequate notice of retrenchment may tantamount to wrongful dismissal.

TABLE 5 - H1: EXAMPLE OF CASUAL EMPLOYMENT FORM

CASUAL EMPLOYMENT FORM *(to be completed in duplicate)*

Original to Employee

Duplicate to Employer

EMPLOYER (CONTRACTING COMPANY):

....

PROJECT:	**EMPLOYMENT NO.:**
REF. NO.:	**DATE:**
Name	**Sex:**

1. You are hereby offered employment with casual conditions as a .... *(labour category)* with effect from ....*(date)*

2. The terms and conditions of employment are as follows:

a) You will be paid Ug Shs. .... per working day or an equivalent task rate.

You will not be paid for public holidays or any day not worked regardless of the reason.

When injured at site during working hours, medical bills will be paid for by the employer named above.

b) You will be paid your wages every ....

c) You are not entitled to annual leave, housing, transport or any allowances.

d) Your employment will be determined by any of the following:

- At the end of the work programme or works for which you have been engaged
- At any time at the discretion of the employer
- Absenteeism without good reason
- When you do not follow instructions from your supervisors
- After a period of .... days.

e) You are responsible forany loss or deliberate damage of tools issued to you and the cost of such will be deducted from your pay.

3. By signing this employment form indicated that you agree with the terms and conditions of employment set out above.

Employers representative:	**Date:**

Acceptance of offer:

I have read and understood the terms of employment offered to me and hereby accept to abide by the terms and conditions set therein.

Name: ....

Signature:...

H1.5 DETOURS AND WATER DIVERSIONS

Detours

To minimize the inconvenience to road users or reduce accidents because of the large number of labour involved, the road should be closed to through traffic whilst under construction. When this is done, detours or diversions which are alternative roads or routes used when the usual one is closed to traffic are provided.

An existing road or a newly constructed route may be used as a detour or diversion. In such a case the road to used must be constructed and or maintained to ensure that the normal traffic is not severely interrupted by the condition. Trained personnel will be required to direct the necessary alternating traffic in one-way traffic. In some cases, the road under construction will be worked on one side while the other side is used by traffic. Any diversions or detours for traffic use must be signed as appropriate and assistance from the District Local Government Administration sought to enforce these measures.

Water Diversions

When constructing drainage structures where there is excessive water, temporary water diversions will be required. The contractors site staff should ensure that the right choice of design and construction for water diversions are made in order to minimise cost on such temporary constructions. Where such diversions have been made, appropriate informative/warning signs must be provided. Water diversions must be closed and reinstated after the completion of construction works.

Section H2

Site Administration

Section H2
Site Administration

H2 SITE ADMINISATRTION

H2.1 RECORD KEEPING

General

One of the key duties for supervisors on site is to keep adequate records on site. Good record keeping system will ensure efficient operation of activities requiring records. The supervisors site records will be used:

- For appraisal of work progress at any other time.
- For fixing rewards and penalties to workers on site depending on performance and behaviour.
- As basis of payments for work done on a job.
- To determine levels of stores (such as materials and worn out spare parts) and form basis for their order or replacement in good time.
- To review assumptions made during design and form basis to make improvements
- To form source of information on behaviour of the completed works.

Site records include, but are not be limited to, the following, and should reflect the requirements of the client..

- **Diaries**- Activities on site, plan used, labour records, conversations, visitors records, meetings.
- **Reports**- Daily, weekly and monthly reports prepared by contractor, Inspectors' daily reports, Engineers' reports,
- **Registers**- Drawings, sketches, schedules of jobs, letters, instructions, issues, stores ledger, receipts, notices, inventories of office equipment.
- **Drawings**- Drawings, built drawings etc.
- **Measurement**- Valuations, financial reports, labour and plant returns, daily record sheets, day work sheets, rate.
- **Plans**

All records must be kept methodically from the start of the contract. A list of all files, drawings, note books, forms etc., shall be referenced to the project by name and job number.

Dairies must be in bound books with pages numbered, they must be kept up to date, written in ink and ruled off after each day's entry. There must be no spare lines where items could be subsequently added. Dairies must never be changed retrospectively.

The Stores Ledger

Storekeeping is easy when you have an organized tool and equipment record keeping system. In the stores ledger book, you record the number of tools that have been received from and sent back to the main head office. In the balance column of the ledger is where you record the number of tools and equipment being held in the site store. Each issue and receipt of tools and equipment should have a delivery / issue note in the delivery note book. Daily tool issues are also recorded in the stores ledger book.

The stores ledger book should be checked at every end of week by the storekeeper and foreperson to ascertain any tool losses and take remedial action. The number of tools issued to and received from each labourer are counted and compared. If these don't balance then the labourer is held accountable for the missing tools.

A list of all labourers who have lost tools is then prepared at every end of month. The list is then given to the paying officer before he starts payment so that he can deduct the cost of the tools from the affected workers. Labourers must be given a receipt for any money deducted from their wages due to loss of tools.

Delivery and issue notes are made in triplicate every time tools are transferred between the head office and the site store.

One copy is left in the book while the other two copies are sent together with the tools to the main store. On receipt of the tools at the head office, the store keeper signs both forms and then retains his copy and then sends the other copy back to the site.

TABLE 1 - H2: STORE LEDGER SHEET

MELTC MODEL ROAD

Page ....of......

GENERAL PERIODICAL STORES ISSUES

ROAD NAME: STOREKEEPER: PERIOD:

STORE LOCATION: ASS. FOREMAN:

Date of issue	Item issued	Qty issued	Condition on issuing	Date of return	Remarks	Name of person issued with goods	Signature of person issued with goods

TABLE 2 - H2 SITE STORE ISSUES FORM

MELTC MODEL ROAD

DAILY SITE ISSUES

DATE :

	TOOL ITEM	20 litre water jerricans		Camber templates		Cups		Ditch & slope templates		Ditch templates		Hoe handles		Hoes		Line levels		Mattock handles		Mattocks		Mortar pans		Nylon rope 200m		Panga		Pick axe handles		Pick axes		Profile boards		Rakes		Ranging rods		Round nose shovels		Slasher		Slope & camber template		Spirit levels 4 ft		Square nosed shovels		Tape measure 30m		Tape measure 5m		Wheelbarrows		Square-nosed shovels		Axes							
	Name	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return	Issue	Return
26	GIMONO MADINA																																																													
27	KASAKYA ROBERT																																																													
28	KIRUDA EDWARD																																																													
29	WAGIDEBO DAVID																																																													

H2.2 SITE WORK PLANS, REPORTING AND MONITORING

Site Work Plans

If the work is to be well organized it is essential that a plan is made well in advance. Without proper planning the job will be slow and expensive.

Work Programme

The overall plan of the construction or works consist a list of dates against operations or activities that should be completed. The work programme may seem simple when presented in its final form but inspection in detail will reveal that it represents a great deal of careful calculations and decisions. More detailed calculations may translate these dates into a bar chart which sets out the programme in visual form and also permitting the rate and duration of working on particular operations to be written in **Figure 1-D4** shows a typical work programme.

Daily Site Plans

Monthly, weekly or daily site activity or work plans are extracted from the overall construction programme by the contractors' staff for implementation. The site activity or work plans have to be ready before the commencement of the particular works or activities. The contractors' site forepersons are responsible for the day-to-day preparation of such plans. Any outstanding works of previous day(s) must be taken into account. Resource deployment changes may occur if there is need to cope up with programmes.

Site Progress Reports and Monitoring

The contractors and the engineers' site staff must measure and report completed works in each day, week and month. Reports must detail the works undertaken and problems encountered. The monthly and weekly reports are generated from the daily reports. The site assistant forepersons or inspectors must prepare daily reports and compile weekly reports promptly. The Foreperson or the Engineer will use weekly reports to produce monthly reports. This monthly report is to be issued to the Project Manager or Engineer at the Headquarters and used to compare progress against the contractors approved work programme.

H2.3 SITE INSPECTION

Site Inspection is carried out by the contractor or the Engineer. Inspections are carried at different times as before tender by the contractor and during supervision by the Engineer or his/her site staff.

The contractors' assistant forepersons on site must ensure that they carry out inspection of all work activities of the day before commencement, during the work and after completion of all tasks. There must be notes made on each inspection. An inspection checklist must be kept.

The project Engineer must prepare an inspection check list of work items or activities he/she and his/her staff will check during each inspection.

TABLE 3 - H2: DAILY PLAN AND REPORT FORM

DAILY PLAN & PROGRESS REPORT

Road number:______________________ Date:______________________

Road Name:______________________ Project:______________________

		Plan				Actual			
		Unit	Task Rate	Wd	Qty	Wd	Qty	From	To
1	**PREPARATION**								
1.1	Setting out								
1.2	Bush/Grass clearing								
1.3	Grubbing								
1.4	Tree/stump removal								
1.5	Boulder removal								
	SUB-TOTAL								
2	**EARTHWORKS**								
2.1	Slotting								
2.2	Excavation to level<250mm								
2.3	Excavation to level>250mm								
2.4	Mitre drains								
2.5	Wheelbarrow Haulage								
2.6	Side borrow								
2.7	Side borrow backfill								
2.8	Ditching								
2.9	Spreading for ditching								
2.10	Backsloping								
2.11	Sloping								
2.12	Camber Formation								
2.13	Reshaping of road								
2.14	Compaction								
	SUB-TOTAL								
3	**STRUCTURES**								
3.1	Scour checks (stones)								
3.2	Scour checks (stakes)								
3.3	Conc. Culvert installation 600mm								
3.4	Conc. Culvert installation 900mm								
3.10	Masonry Clay Blocks								
3.11	Masonry Rough Stones								
3.12	Gabions								
3.13	Concrete Class P								
3.14	Concrete Class Q								
3.15	Concrete Class 20								
3.16	Miscellaneous (Repairs)								
	SUB-TOTAL								

			Plan				Actual			
			Unit	Task Rate	Wd	Qty	Wd	Qty	From	To
4	**GRAVEL WORKS (QUARRY)**									
4.1	Clearing of quarry site	1								
		2								
4.2	Quarry access preparation	1								
		2								
4.3	Overburden removal	1								
		2								
4.4	Excavate/stockpile gravel	1								
		2								
4.5	Loading of gravel	1								
		2								
4.6	Quarry backfill	1								
		2								
	SUB-TOTAL									
5	**GRAVELLING**									
5.1	Offload/spread gravel									
5.2	Compaction									
5.3	Miscellaneous (repairs)									
	SUB-TOTAL									
6	**SUPPORT STAFF**									
6.1	Water carriers									
6.2	Base camp activities									
6.3	Other									
	SUB-TOTAL									
7	**HAULAGE EQUIPMENT**		Cap. m3		Haul (m)		Loads (no.)		Hours	
8	**COMPACTION EQUIPMENT**		Type				Hours			
9	**MATERIALS USED ON SITE**		Unit	Qty	Remarks					

H2.4 PAYMENT OF WORKERS

Methods of Paying for Labour

The method you use for paying the labourers can have a major effect on the efficiency of a site. If an effective method is used, profits or savings can be increased at the same time the workers earn more. It is important to pay wage which will attract labourers and is commensurate with production. It is essential to make arrangements to pay all workers **CORRECTLY** and **ON TIME**. Morale will be lowered quickly if payment is delayed or incorrect.

Remuneration of workers is based on:

- Units of time or
- Units of production as measured by physical output.

Therefore, there are two fundamental systems of remuneration i.e. time-based and productivity-based.

Major advantages and disadvantages of the two systems

TABLE 4 - H2: MAJOR ADVANTAGES AND DISADVANTAGES OF THE TWO SYSTEMS

	Time-based	Productivity-based	
	Daily Paid	**Piece Work**	**Task Work**
Major Advantages	Easy book-keeping, simple to organize	Pay relates to output and output can be maximized each day	Where task is set properly, allows the average worker to finish task and go home after six to eight hours of work
Major Disadvantages	High amount of supervision required to maintain reasonable output. Rate of progress can be extremely variable.	Tendency of self-exploitation as no limits is placed on the amount of work a worker can do. Difficult to control by government administration.	Requires close supervision and monitoring in the daily laying out of work and overall setting of task size. Possibility of exploitation.

TABLE 5 - H2: RECOMMENDED PAYMENT FREQUENCY

Payment for:	Recommended Frequency
Wages for laborers	Payments Monthly to save labourer's earnings
Materials supplied	Payments within two weeks
Equipment	Not later than 30 days from date of invoice
Rent for site camps	Payments can be monthly, quarterly or annual depending on the contract period.

Modes of Payments

TABLE 6 - H2: MODES OF PAYMENTS

Payment for:	Payment Mode
Wages for labourers	Should be paid cash and sealed in customized envelopes as detailed on one face as below.
Materials, Equipment and Rent	Payments should be made by cheque to VAT registered persons / firms or as seen fit.

TABLE 7 - H2: CUSTOMISED PAYMENT ENVELOPE

Name…………………………………………..…		**No.** ……………………………………......…………		
Occupation………………………………………… ...……………		**Month-ending**. …………………………		
Employer……………………………………………………………………………………...………….......- ..				
	Workdays	**Rate**	**Shillings**	**Cents**
Ordinary time				
Overtime work				
Total Holiday bonus Gross Total				
Deductions (specify)				
Amount payable (UShs)				

The officer in charge of payments will inform the foreman when he/she intends to conduct payment. The foreman shall make sure that all the labourers are informed.

If a laborer cannot collect his/her own pay he/she can authorize a friend/relative to collect it on his/her behalf. This person must carry a note signed by the foreman.

If a labourer misses the pay parade, he/she must collect the pay from the office as soon as he/she can. He/she must carry a note signed by the foreman identifying the labourers otherwise the pay will be refused. Adequate security must be provided when handling payrolls and paying labour.

H2.5 SITE MEETINGS

Site meetings are organized between the Engineer, Contractor, Consultant and the Clients representative. Site meetings between the above and communities also need to take place regularly as specified in the contract. It is the responsibility of the Engineer and Contractor to organise or call any such meetings.

Usually prior to any construction there is an inaugural meeting between the engineer and contractor. The Engineer will prepare and document a schedule of all regular contractual meetings to be held with all parties. He/she shall identify typical agenda and chair these meetings.

Progress Meetings

Progress meetings are often held monthly. Minutes of such meeting shall be prepared promptly and distributed to all parties.

Mobilisation and Monitoring Meetings

Following the award of tender/procurement of contract by the client to the pre-qualified contractor, all the relevant stakeholders shall attend a Mobilisation Site Meeting to confirm what were discussed during Pre-Tender Site Meeting, and mobilise the required resources for implementation of works.

Similary after commencement of the works, Monitoring Site Meetings shall be organised monthly with all stakeholders to ascertain the contractors compliance with the cross cutting issues in the contract and inform communities or stakeholders on any other issues that may arise during the progress of works. An information sheet and checklist of these meetings are shown in **Annex 1** of this Manual.

Section H3

Gender and Women's Participation

Section H3
Gender and Women's Participation

H3 GENDER AND WOMEN'S PARTICIPATION

H3.1 INTRODUCTION

Despite the constitutional provisions for gender equality and affirmative action, there are still many constraints to achieving their operationalisation. Gender is a new concept in the road sector that is generally male dominated. The perception is that there are no specific roles for women in road works, which is preoccupied with technical and financial matters. The problem is compounded by the fact that there are indeed very few trained women as compared to men in these fields. This has limited the number of women who would be employed in the roads sector. What has been largely ignored is that when women earn, the money is spent mainly on the family, thereby leading to the improvement in the welfare of the family, which is not usually the case for men.

Originally, incorporation of gender issues in development programmes was donor driven. However of recent, this has become a requirement in nearly all development interventions. Governments have now embraced gender issues and in Uganda, a Ministry has been created to take care of this. Policies and strategies have been developed to address gender issues in different sectors. In the road sector, some of the relevant policies are elaborated as below.

Policy Frameworks

The frame of reference for the formulation of this Manual includes national and institutional policies and strategies that reflect the understanding of gender equality as a human right and development asset.

These policies and strategies include:

- The Constitution (1995)
- The National Gender Policy (1997)
- The National Action Plan on Women (1999)
- The Decentralisation Policy as expounded in the Local Government Act of 1997
- The Poverty Eradication Action Plan (2000)
- The Final Draft White Paper on Sustainable Maintenance of District, Urban and Community Access Roads (2001)
- Development Aid Policy

H3.2 MAINSTREAMING GENDER ISSUES IN ROAD IMPROVEMENT CYCLE

The activities for mainstreaming gender in road improvement cycle has been elaborated in the following key programming areas as planning, implementation and impact evaluation. The activities are described as below:

Planning and Preparation

At the planning and preparation stage, activities include Annual District Road Inventory and Condition Survey (**ADRICS**), road prioritisation and selection, contractor procurement, mobilisation and sensitisation. The section outlines how to integrate gender in the planning and preparation stage in road improvement cycle.

ADRICS

ADRICS (refer to District Road Works Manual **Volume 1 Manual B**), which involves collecting/ updating data on road condition including collection of socio-economic data (using **Form C**), is one of the major planning and preparatory activities for road improvement activities.

In carrying out the **ADRICS**, the process shall:

- Take into account women-specific transport needs by ensuring that women are involved in sub-county inventory. During preparation for undertaking **ADRICS**, women shall be deliberately mobilised by the sub-county staff to participate in sub-county inventory
- Include women's views in data collection through their participation in sub-county inventory. There shall be a deliberate effort to encourage women to participate
- Use gender dis-aggregated data in analysis

The District Works Departments shall work with the Community Development staff at this stage to ensure that gender issues are part of the process. The Engineering Assistants and the Road Inspector with the support of the Community Development Assistants shall undertake the sub-county inventory (for socio-economic data collection).

The District Works and Community Development Department staff at district and sub-county levels shall do the activity routinely at the beginning of each planning cycle.

Road Prioritisation and Selection

The Rehabilitation and Maintenance Planning System (**RAMPS**) programme has been developed for use in prioritisation of roads for maintenance and rehabilitation. As the districts employ **RAMPS** programme to prioritise roads, other qualitative factors shall be taken into consideration. This shall include the use of socio-economic data generated in sub-county inventory during **ADRICS**, which includes the views of men and women including their transport needs. For instance what would be the implication of improving a road section to men and women or who is likely to benefit more from an improvement of a road section? These are some of the questions that must be answered if road prioritisation and selection is to be gender sensitive.

Sensitisation and Mobilisation

Various studies and stakeholder workshops[1] indicate that there is poor awareness of gender inequalities in general and of the potential benefits of involving women in labour-based road works in particular. There is need to mobilise and sensitise the stakeholders at district and sub-county/local level prior to road improvement works to increase awareness on general gender issues and more so enlist genuine women's participation in road improvement process. Sensitisation and mobilisation shall be conducted at various levels and shall target different groups as below.

Gender issues in road works and women's participation shall be part of sensitisation and mobilisation campaigns conducted at community and sub-county levels (to target sub-county works or general-purpose committee, members of the communities who are potential workers, sub-county officials and politicians) in those sub-counties where roads works shall take place. This may be done through community meetings, radio programmes and display of posters.

After selection of roads for improvement, potential beneficiaries, sub-county officials and politicians in concerned communities and sub-counties shall be mobilised. This shall be done as part of the community meeting refered to as **Mobalisation Site Meetings** (refer to information sheet and checklist in **Annex 1** for details).

Mobilisation Site Meetings shall be held prior to the beginning of road improvement works by the Contractor. During the meeting, 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. The Community Development staff shall also use this opportunity to carry out a gender needs assessment using a Gender Needs Assessment checklist provided for in **Annex 3**. Strategies on how to address gender issues and women's participation during road works shall be part of the discussions.

During road improvement works, the Contractors and workers shall be sensitised on gender issues and women's participation during **Monitoring Site Meetings** (refer to Information Sheet and Checklist in the **Annex 1**). Monitoring Site Meetings shall be convened on a monthly basis to monitor progress in the works and check compliance with crosscutting issues. During such meetings, the District Engineering and Community Development staff shall ensure that gender issues are presented and discussed as provided for in the Information Sheet and Checklist for Monitoring Site Meetings. The Contractors shall inform the meeting on how they are addressing gender issues in general and women's participation in particular.

The community development staff based at the sub-counties shall further undertake mobilisation and sensitisation campaigns through sensitisation meetings, display of posters, and radio programmes. The timing shall be after selection of roads for improvement (**ADRICS**/**RAMPS**) and before mobilisation

Contractor Procurement

The process and end result of contractor procurement from pre-qualification to tender award shall be gender sensitive. Efforts shall therefore be made to have a District Tender Board which is gender sensitive (Where possible the districts shall be required to have their Tender Board members sensitised on gender issues).

Pre-qualification of contractors will favour those who shall demonstrate capability and willingness to address gender issues. The Detail analysis form (**DAF**) must be gender sensitive (Refer to **Volume 2 Manual A1**).

In addition to technical and financial evaluation, Tenders shall be evaluated in regard to their response to gender related issues and their proposal of ways to secure gender equity and gender balance. During evaluation, first priority shall be given to contractors willing to use labour-based technology, which is a prerequisite to addressing gender issues. Other factors to be considered shall be availability of female technical staff, willingness to employ women and method of work e.g. task allocation and other forms of support to female workers.

Training

Gender and women's participation is an integral part of the technical training provided at **MELTC**. Gender and women's participation has been provided for in the **MELTC** Curriculum. The implication is that whoever goes for training at **MELTC** shall receive training in gender issues and women's participation in labour based road works. It will be the responsibility of the districts with the advice of the District Engineer to screen and send contractors, district staff and relevant political leaders for training at **MELTC**. In doing so, the districts must ensure male and female representation.

H3.3 IMPLEMENTATION OF ROAD WORKS AND SUBSEQUENT MAINTENANCE

Where appropriate, Labour-based methods shall be used in district road improvement works. During implementation of construction or improvement works, monitoring and reporting are essential follow up process to ensure that activities are being undertaken according to plan or specifications, including compliance on gender issues. Mainstreaming of gender issues at the road improvement stage is action-oriented and is elaborated as below:

Road Improvement Works

During road improvement works, contractors must endeavour to comply with gender issues in the areas of:

- 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

Recruitment of Workers

After mobilisation and sensitisation of the stakeholders, especially those at the sub-county levels and communities, recruitment will follow. Often mobilisation mechanisms are not sensitive to the needs of women and therefore, in most cases there is low turn up of women seeking for recruitment. Recruits should be done according to the guidelines described in **Section H1** and in manner sensitive to the requirements of women and men.

Work System

For efficiency to be realised in labour based construction works, it is important to achieve high labour productivity. It is therefore imperative that only work system providing incentive for good work output is used. The basic schemes currently used in labour payment include:

- Daily payment whereby workers are paid an agreed sum of money each working day in return for a fixed number of hours.
- Piecework whereby workers are paid an agreed sum of money per unit of output. The daily output is usually left to the discretion of the worker.
- Taskwork whereby workers are paid a fixed daily wage in return for a fixed quantity of work.

While the dispersed nature of site activities makes supervision of daily work difficult, this would provide the greatest output incentive to labour.

The task work system is based on the output achievable within a working period of 8 hours. However, individual workers may work more intensively or devise a means of achieving the task in less time. For example, a worker may decide to hire fellow members of the community to assist with allocated task. Apart from being highly productive, this would allow workers to be released for their own activities as soon as they have satisfactorily completed their task unlike in the daily paid system that would require the worker to wait for time to elapse.

This makes it the most suitable work system for women with competing domestic responsibilities.

Flexibility in Working Hours

Flexibility in working hours is when the contractor allows workers to undertake their task at whatever time they feel convenient, provided it would be within the time limit that would allow the contractor staff to provide supervision.

Though not commonly in use, it may be adopted for labour-based road works. Flexibility in working time should be encouraged and used where possible except for where activities are difficult to measure. This should be used in combination with task works system, which may not be restricted to fixed working hours.

In addition to task work system, the contractors using flexible working time are likely to attract more women. This is because women may not be able to come to work early and would need to go back to their homes before the official time to attend to domestic responsibilities.

Provision of Special Facilities for Men and Women

Some of the key facilities provided at work sites (discussed under work place safety and health) include sanitary and protective.

It is common practice for sanitary facilities to be provided generally for both men and women. This has often resulted in the female workers fearing 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, the cost of which should be included in the bills of quantities.

In order to encourage and support breast-feeding mothers to work, contractors should construct temporary shelters for baby sitters and children from sun heat and rain, the costs of which would also be included in the bills of quantities.

For ease of monitoring, all the above are included in the contract administrative documents, especially Conditions of Contract (**Volume 2 Manual A1**). The district technical staff, especially those from community development will use the Conditions of Contract document to monitor contractors' compliance with the gender issues.

Contract Administrative Documents

In the contract procurement and administrative process, the contractors will have to be reminded of gender issues from the outset through pre-tender site meetings and as he/she is about to begin works through mobilisation site meetings. Monitoring and followup will need to be undertaken to ensure compliance throughtout the implementation stage.

The instructions to tender and the conditions of contract documents must specify the contractors' obligations to:

- Inform women of employment possibilities and to actually employ as many women as possible
- Also employ women in all positions such as supervisors and head-persons and allocate to them non-traditional tasks.
- Contractors must keep muster roles that indicate this
- Pay men and women equal salaries and maintain pay roles that indicate this
- Operate with flexible working hours and take into consideration seasonal agricultural cycles and women's productive and reproductive roles
- Operate with home/community-based labour and not with permanent labour gangs
- Provide facilities specifically required by women (safe toilets, washing places etc.)
- Co-operate with NGOs and Community Development Department to secure availability of gender expertise, and community participation skills etc. when required (e.g. to mobilise for increased participation of women, mediate in conflicts etc.)
- Provide on the job training of women (if and when required) and secure training of women in supervisory positions
- Prepare and train especially women in subsequent routine maintenance
- Provide for and participate in regular meetings with the communities with participation of all relevant district and sub-county staff. The meetings will serve among others to enable participation of communities in decision making and supervision (*see below*) through sub-county works committees, but also to disseminate the information about the causes and prevention of **HIV/AIDS**.

These activities are the responsibility of the District Works Departments with support from the gender officer/community development officer.

H3.4 MONITORING AND REPORTING

Monitoring and reporting will be on Contractor's compliance with gender issues in road works.

This shall be based on monitoring mechanisms to include but not limited to monitoring site visits and meetings (refer to **Annex 1** for details). Monitoring site visits shall be done regularly on a monthly basis. This will be by Community Development staff and Sub-county Works Committee. Monitoring Site Meetings shall precede site visits.

Minutes and reports will elaborate on the quality and quantity of gender issues addressed in the key areas mentioned above. Monitoring site meetings shall be attended by among others the community development staff, members of works committees, workers' representatives and members of the community. Apart from the general discussions of crosscutting issues, specific focus shall be on gender issues especially progress being made on female workers recruitment, task allocation and working hours including provision of special facilities for women. The District engineering staff shall use Gender Compliance Monitoring and Evaluation form to collect data on the extent of Contractor's compliance with gender issues (refer to **Annex 2** for details). This shall be the basis for the payment of the last certificate.

H3.5 IMPACT EVALUATION

Data collection for baseline surveys and impact evaluation shall be gender dis-aggregated (e.g. distinguish between male and female pedestrians, male and female use of transport means etc.), include gender indicators and take women's needs and views into consideration.

The baseline survey form attached includes provisions for tracking gender relevant issues, in particular the effects of the road improvement on women's work burden and transport patterns (male and female pedestrians, bicycles use, other transport).

1 IT Transport: Studies for the Road Sector Support Programme, Study Report on Environmental and Gender Action Plans, May 2000; Reports on Stakeholder Workshops on Gender Management and Action Plans, May and September 2000 and March 2001.

Section H4

Environmental Issues

Section H4
Environmental Issues

H4 ENVIRONMENTAL ISSUES

Introduction

Ever since the publication of the Brundtland report and the UN Earth Summit in Rio de Janeiro[1] environmental problems and environmental sustainability have been on the international agenda. National governments have increasingly 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.

It is generally noted that, across the donor community and national governments, environmental and other crosscutting issues need to be mainstreamed into the development process. In Uganda, the basis for mainstreaming environment issues can be summarised as legal and policy obligation, reduction of costs, improved corporate image, and reduction in environmental and health hazards.

H4.1 MAINSTREAMING ENVIRONMENTAL CONCERNS INTO LABOUR-BASED ROAD WORKS

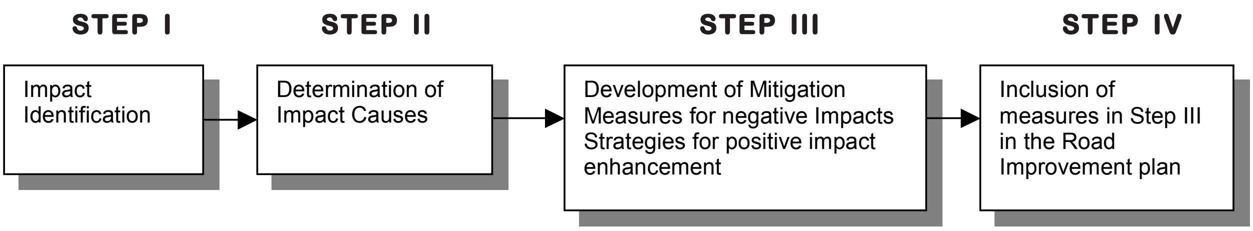
Environmental concerns need to be identified before road improvement works begin to avoid them becoming apparent during improvement/maintenance works. The environmental concerns identification process requires consideration of the entire road environment not only to focus on single items like the road reserves borrow pits etc. Therefore, the mainstreaming process should be Multi-sectoral in approach to be able to capture a wide range of impacts.

Environmental concerns can be mainstreamed into the road sector activities by the following steps namely:

- identification of potential or existing impacts
- establishment of the causes of the impacts above
- development of remedial or mitigation measures for the negative impacts
- determine ways/means/strategies for the enhancement of identified positive impacts

Once mitigation or enhancement measures have been developed, and their feasibility established (*are they realistic, achievable, etc...*) they can then be incorporated (mainstreamed) into the road improvement programme.

These can be summarised diagrammatically as below:



When to Mainstream environmental Concerns in Road Works/LBRWs

The road improvement cycle has four elaborate phases; Planning, Detail Design, Implementation, Evaluation. Each of these phases has to mainstream environmental concerns into its activities.

H4.2 PLANNING AND PREPARATION

Activities under planning and preparation include **ADRICS**, road prioritisation and selection, design, preparation of contract documents, sensitisation and awareness raising and contractor procurement. All these stages need to address environmental concerns as elaborated below:

ADRICS

ADRICS (refer to **Volume 1 Manual B**), which involves collecting/updating data on the road condition including collection of socio-economic data (using **Form C**), is one of the major planning and preparatory activities for road improvement activities.

In carrying out the **ADRICS**, data shall be collected on environmental indicators, which could include but not limited to:

- Scope and the nature of work in respect to the environment
- Influence of the work on
    - Protected areas (forest reserves, game 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 improved road.
- Public health impacts
    - noise levels
    - dust levels
- Alternative re-alignments and their environmental implications.

Depending on the magnitude to the impacts anticipated an approval from **NEMA** shall be sought at this stage.

Relevant mitigation measures shall be made part of the prioritisation 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 part of the parameters for prioritisation of road and road works taken into consideration.

After the selection and approval of roads for improvement, another major planning activity is conducting of detailed surveys and design of the technical works. From the outset the design shall incorporate any necessary environmental mitigation (or enhancement) measures. Mitigation measures to be included in the design shall be drawn by the District Engineer and the Environment Officer with the participation of any other relevant technical person such as the Consultants experts. Attempts shall be made to involve the local peoplein the process to make use of the local knowledge. Where environment committees exist, they shall also be involved in **ADRICS**.

Sensitisation and Awareness Raising

Studies and consultations with stakeholders indicate low levels of awareness of good environmental practices in the road sector. Sensitisation and mobilisation shall be conducted at all levels and should target different groups including politicians, local leaders, contractors, general population and the labourers.

After selection of roads for improvement, mobilisation and sensitisation will follow. Sensitisation on "environment issues in road works" shall be conducted as an integrated part of community meetings referred to as **Mobilisation Meeting** before the commencement of road improvement works. Sensitisation shall also take place through other mobilisation campaigns at the community levels.

At the district level, sensitisation would be the responsibility of the District Works Departments assisted by Environment Officers. At the sub-county and community levels, this shall be the responsibility of the relevant sub-county staff with the involvement of the Sub-county Works/General Purpose Committee.

Contract Procurement

The entire contract procurement process (from pre-qualification to tender award) is to be environmentally sensitive. Efforts shall be made to make the District Tender Boards environmentally sensitive and knowledgable in Environment issues.

Pre-qualification of contractors will favour those who shall demonstrate capability and willingness to address environment issues. The District Engineers shall ensure that the Detail Analysis Form (**DAF**) incorporates environmental issues (Refer **Volume 2 Manual A1**).

During contract procurement, the Tenderers shall be reminded of environmental issues through **Pre-tender Site Meetings**. Pre-tender Site Meetings are held prior to the Tenderers preparing tender documents to verify the situation on the ground regarding physical works. This also provides an opportunity for Site Investigation on availability of and access to materials, safe water source, labour availability, campsite location, availability of storage facilities, and crosscutting issues related to road works among others. This means the Tenderers shall go into the bidding process when they are well aware of the environmental issues.

In addition to technical and financial evaluation, Tenderers will be evaluated in regard to their strategies on how they plan to address environment-related issues on the project. For instance, during evaluation, priority shall be given to contractors willing to use labour-based technology, which is environmentally friendly and proposal for availability of a part-time Environmentalist on the list of staff.

The District Tender Board based on the advice and recommendations provided by the Technical Evaluation Team and the District Works Departments will take the final decision as to contract awards.

Training

Environmental awareness promotion is already an integral part of the technical training provided by some institutions including **MELTC**, a national institution responsible for all training related to improvement and maintenance of district roads. This shall be further strengthened through other means such as follow-ups and on-the-job training of contractors by the district technical staff.

H4.3 IMPLEMENTATION OF ROAD IMPROVEMENTS AND SUBSEQUENT MAINTENANCE

The Government of Uganda through the MoWHC and the District Local Governments have endorsed the use of labour-based methods in road maintenance, which causes less environmental damages and therefore environmentally friendly.

During road 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 road works are executed. In all, negative impacts can be avoided or reduced by making provision for them during planning and design stage in road improvement process. Some of the examples of temporary negative impacts may include:

- Dust from haulage vehicles
- Sound pollution from heavy equipment
- Overexploitation of water sources by use for road construction
- Pollution of water sources from oil spills

Examples of permanent negative impacts are:

- Loss of vegetation cover
- Damage to wetland resources
- Erosion
- Unrestored borrow pits
- Drainage into agricultural land
- Disruption of livelihoods of those settled along improved roads

Below is how some of the common environmental problems can be addressed:

Borrow pits

In order to restore the borrow site, the following actions shall be done:

- Collect all the vegetation matter on the site (grass, shrubs and possibly tree materials). This should be stockpiled aside near the pit.
- The topsoil for instance, black layer of soil should be collected on a separated side. Sides of the pile are protected. Topsoil has seed bank that could help re-vegetation of the site.
- Also the subsoil materials be stockpiled separately once excavated.

After extracting murrum, the area should be restored as follows:

- All unused murrum boulders 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).
- Levelling 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, sodds (stems) of elephant grass for instance, (*Pennisetum purpureum*) can be planted on the site.
- Depending on the landowner, it is advisable to plant some tress on the site especially, when the site is extensive to facilitate the area to blend well with the adjacent areas. Preference could be for indigenous trees, which do not require serious husbandry.

Prevention of Soil Erosion

In road works, soil erosion can arise through the following ways:

i) Roadside / embankments

Where a road is raised (through wetlands or depressions), the edges of the road slowly erode and can keep slowly breaking off.

How to control this erosion

- Creeping grass such as tufts of *Cynodon dactylon* are dug and planted on such surfaces. This grass is a creeper and its stems easily establish thus, forming a cover over such surfaces.
- It is also possible to collect seeds of grass such as *Sporobolus pyramidalis* and broadcast on the edges of the road. It is important that tall grass should not be planted, as these will form thick stands, which affect the safety of road.

ii) De-silting of roadside channels

However, regular dredging tends to lead to formation of heaps of soils and silt at the side of channel, which is again washed, back to the channels during the rains.

Once the channel is dredged, the soil removed should be spread backwards to avoid formation of silt/sand mounds which are dangerous to livestock.

Reduction of the level of erosion in watercourses can also be achieved through locally interwoven scour checks made of sticks and placed at specific intervals depending on the gradient. These can trap eroded materials and regularly removed by de-silting.

iii) Erosion from loose soil

This is common during re-graveling of roads in which soil is left loose and where, graders are used to open drainage channels. Such surfaces are prone to erosion.

To reduce erosion on such surfaces:

- after opening of channels with graders, the area should manually be levelled and loose soil evenly spread at the back of the channel.
- after grading, the surface should be levelled, sprinkled with water using water bowzers for stabilisation and compaction of loose soils done.
- the contract should include grass planting on some exposed surfaces to help bind loose soil and reduce soil erosion

iv) Erosion from open cut surfaces

In areas of high altitudes and in hilly areas where hills are cut, resultant open surfaces are prone to erosion. Creeping grass should be planted at the edges of the cut surface. When established, the creeping 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).

Grass cutting

During road maintenance, especially through slashing, the cut grass can be a cause of accidents to road users, especially pedestrians, cyclists and motorists. Road workers may injure road users either with the tools especially slashers or indirectly by flying stones.

Mitigation

Workers should be guided on how to face in relation to the road during the slashing:

- Slash facing the road and starting from the edge of the area under maintenance and progress towards the road edge.
- After slashing, vegetation that has landed on the road should be removed.
- Burning of cut vegetation next to the road side should be avoided to reduce the risks of accident and loss of property from fire. The road side smoke may also impair vision leading to traffic accidents.

Loss of agricultural land

Loss of agricultural land sometimes, with crops can result from a number of ways such as:

- **Through establishing borrow areas**
  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. In some cases borrow pits are left barren and agriculturally unproductive.
- **Minimising road re-alignments**
  Where necessary, the road alignments should be minimised to those planned. Adequate warning should be given to landowners with crops on the areas to be affected in order to reduce loss of crops.

Contamination of soil/water (environmental pollution)

Water and soil often get contaminated through petroleum wastes (oil, grease, fuel, etc) from service of vehicles and road works equipment. In some cases mitre drains may direct dirty water from the road into drinking water wells/sources.

Mitigation

- Contractors should ensure that, servicing of the road works equipment is undertaken at the campsites where oils are centrally collected and disposed off.
- Once vehicles/field equipment breaks down, it should be towed to a service bay at the camp site for repairs
- Where it is inevitable to service the vehicle/equipment on the road, the waste oils should be carefully collected and taken to camp site for storage
- Environment Inspectors/Officers in the district should monitor the project in their areas for any environment infringements

Health Hazards from Dust

During road works and all its associated improvement works, the transportation of construction materials through villages by the haul vehicles leaves clouds of dust that can be hazardous to the health of the local population.

Mitigation

- The route should be sprinkled with water thrice a day (in the morning, midday and 3 o'clock). The sprinkling should be light in order not to lead to flooding of the road, which can lead to slipping off the road by various forms of traffic.
- Humps should be erected on the access routes to serve as speed regulators in order to reduce dust production

Disturbance to Protected Areas (Forests or Game Reserves)

Gravel road works normally have minimal impacts on wildlife and forested areas in terms of destroying wildlife and encroachment to ecosystems. Related problems include:

- Road workers on roads who pass through protected areas may be tempted to trap wild animals especially the birds and small mammals such as guinea fowls, franklins, edible rats, the dick-dicks, rabbits, and antelopes among others. They are also likely to exploit other forest resources at the expense of the protected area.
- Sometimes, the road workers may give foods like bananas to wildlife like baboons, thereby attracting them to roads. The wildlife are likely to maintain their presence along the road side in the end endangering their life in terms of accidents from the fast moving traffic as a result of improved road.
- Disruption of wildlife and forest ecosystems along the road especially in the process of widening or establishing road reserves. Such activities lead to increased loss of arboreal wildlife, which would be crossing the road through the canopy, which is then lost.
  (e.g. Kampala - Jinja highway at Mabira Forest where forest cover along the road was cut to clear the road reserve)

Siltation of Wetlands

Wetland siltation arises in road works especially in the construction of bridges. The earth works leave exposed surfaces of soil open to erosion. The sides of the wetland where earth works end should be protected with stone gabions. Grass should be planted above the stone gabions.

Open earth works surface should be planted with grass to reduce erosion. Creeping grass such as paspurum or star grass should be planted.

Interference with Socio-Cultural and Historical Sites

Sometimes realignments needed during road improvement or reconstruction may pass through trees or sites of socio-cultural sites. In that case, the following should be observed:

- Before the final design of the road works, social, cultural and economic data related to the road should be collected. This should include but not limited to the cultural sites and their distance from the road, historical sites such as caves with ancient paintings.
- Identified sites should be mapped out with attempts made to avoid felling trees unnecessarily. (Examples include trees with socio-cultural and economic values such as shea butter trees in northern region and *Ficus spp* in Central region)

Road Accident Risks

Road accident risks are a potential danger during road works and its subsequent usage. During road works, the road repaired is open to traffic and a host of other road users. To prevent accidents occurring on roads under repair:

- 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 and murrum 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 (such as murrum moulds)

Camp Sites

In most of the road projects, campsites used for the road project are often left undemolished. The abandoned site can have buildings, old trucks or their parts, concrete floors and a host of other items originally associated with the road project.

Strategy

i) The Contractors should always prepare Decommissioning Plans, which define how the site will be restored. **NEMA** should approve the plan.

ii) Demolition of Sites

The key point to consider include:

- Safe distance from the structures must be established to eliminate the hazard of debris falling on workers or the public during the process
- Competent persons to lead demolition must be identified
- The site should be inspected before hand
- Utilities such as water and electricity must be disconnected
- Establish sites where the materials can be deposited

Management of Stone Quarries

Stones are prime materials in road construction and related improvement works. Stone is used for aggregates of varying sizes, stone dust used as primer on the tar. The process of extracting and processing the stones has a number of far reaching environmental impacts to the community and the workers on the quarry. However, common problems have remained mainly to be the quarry site management after the work.

Concerns on Quarry Pits include:

- Dangers of the gapping holes/pits where stone is extracted from
- Large unused stone boulders which remain on the site may roll causing accidents or damage property.
- Eroded loose stone aggregates and stone dust which sometimes end in gardens, and even, in wetlands or swamps
- Public utilities which remain undemolished
- Large and obsolete stone processing equipment
- Loose aggregates which are spread on the site to provide operation ground
- Waste oil spillage staining the site

H4.4 CONTRACT ADMINISTRATIVE DOCUMENTS

Environment issues shall be addressed in all stages in the planning and implementation of road works.

From the outset, pre-qualification of potential contractors will take into consideration the environmental responsiveness of contractors.

In contract procurement and administrative process, the contractors will have to be reminded of environment issues form the outset through Pre-tender Site Meetings and as he/she is about to begin works through Mobilisation Site Meetings.

Further reminders and monitoring of contractors for compliance shall follow through monitoring site visits and meetings. For these to flow smoothly, they shall be provided for in the contract documents.

The instructions to tender and the conditions of contract documents must specify the contractor's obligation to:

- Apply more environment-friendly labour-based methods whenever the character of work allows. The specifications should clearly indicate which works shall be carried out with labour-based methods.
- Protect and re-establish natural environment, and mitigation of damages to the natural environment.
- Maintain environmental due diligence as defined by the environment laws and regulations of Uganda
- Propose in writing the location of site installation including sanitation facilities, and the measures to be taken to minimise impact on the environment and the people living in the area with regard to surface and underground usage such as bush clearing, tree removal, drainage and garbage disposal, disruption of water table, and ground water pollution;
- In case of excavation of material from quarries and/or borrow pits, ensure the preservation of trees, facilitate water percolation and natural vegetation growth, drainage ditches, and restoration of site to original appearance.

It is important that the relevant technical staff (engineering and environment) make the necessary follow up to ensure contractors' compliance.

Supervision of Works

Prior to commencement of road works the Environment Officer shall inspect the site to:

- Make an inventory of the sites to collect baseline information for post-construction evaluation. All the three parties – District Engineer/Environment Officer, contractor and communities represented by the Sub-county Works Committee, will sign the inventory (refer to **Annex 1** for Checklist)
- Assess potential environmental risks resulting from road works and instruct the contractor on measures to be taken to prevent or mitigate them. In special cases the Environment Officer will request that **EIAs** to be carried out.

In addition to the supervision of the qualitative and quantitative aspects of construction activities, supervision will also include compliance with the contractual obligation as regards the natural and working environment.

Supervision of works shall be done in the following ways:

- Mobilisation site meetings conducted between the Contractor and District Works Departments. The purpose of the meeting shall among others be to discuss local environment problems and mitigation measures with the stakeholders before commencement of works. This will provide the sub-county and community stakeholders with a flat-form to give their views on local environment issues, which will partly become the benchmark for supervision and future assessment of the extent to which environment issues have been addressed.
- Monitoring site meetings shall be convened regularly, preferably on a monthly basis as a means to supervising the extent to which contractors are meeting their contractual obligations in complying with environment issues in the course of carrying out works. The monitoring site meeting shall provide an opportunity for co-operation and interaction between the contractor and the communities through the sub-county Works Committees, who represent the communities as regards road related issues. Other participants in the meeting shall include Environment Officers and Road Inspectors including any other relevant staff.

Handing Over

Prior to handing over of the road works, the environment officer shall issue an "**Environmental Compliance Certificate**" as mentioned in the conditions of contract confirming that the site has been restored to its original condition.

The certificate will be based on the report of the Environment Officer who shall inspect the site before completion of works. Final payment to the contractor shall only be effected after issuance of the certificate (refer to Environment Compliance Monitoring and Evaluation Form in **Annex 3**)

H4.5 MONITORING, REPORTING AND IMPACT EVALUATION

Monitoring and reporting will be on contractor's compliance with gender issues in road works.

This shall be based on monitoring mechanisms to include but not limited to monitoring site visits and meetings (refer to Annex for details). Monitoring site visits shall be done regularly on a monthly basis.

Monitoring site meetings shall precede site visits. Monitoring site meetings shall be attended by among others, the Environment staff, members of sub-county Works Committee, workers' representatives and members of the communities among others. Apart from the general discussions on crosscutting issues, specific focus shall be on progress being made in addressing looming environment issues as a result of road works.

Monitoring reports to be prepared by the Environment Officers will elaborate on the qualitative and quantitative aspects of environmental issues addressed in key areas mentioned above.

Impact Evaluation

Data collection for baseline surveys and subsequent impact evaluation shall be on the relevant environment indicators.

Data collection will be done with district and sub-county technical persons.

1 Uganda has endorsed Agenda 21 of the Summit in 1992.

2 IT Transport: Study Report on Environmental and Gender Action Plans, Studies for the Road Sector Support Programme, May 2000; Report on Stakeholder Workshop on Gender Management and Action Plans, May and September 2000 and March 2001.

Section H5

Labour and Workplace Safety

Section H5
Labour and Workplace Safety

H5 HUMAN RIGHTS, LABOUR AND WORKPLACE SAFETY

H5.1 HUMAN RIGHTS, LABOUR ISSUES IN LBRWS

Introduction

Following the ratification by member countries of the ILO Geneva conventions on Labour issues/standards the application of good labour policies and practices by Governments and organisations have become a human right requirement. These international labour standards may be enforceable under national legislations and laws, and in the case of Uganda, these include:

- The Employment Decree 1975
- Employment Regulations 1977
- Factory Act 1964
- Trade Dispute and Arbitration Act 1964
- Industrial Relations Decree 1984
- National Social Security fund Act 1985
- Trade Union Laws (miscellaneous) 1998
- Workers Compensation Act 2000
- Industrial Training Decree (Apprenticeship and Vocational Training

Labour requirements that must be observed relate to the following:

- labour standards
- Welfare laws
- Social security and Insurance
- Rights of Association
- Occupational Health and Safety

Labour Standards

International labour standards agreed upon by employers, workers and government take standard forms of **conventions and recommendations**, that become binding and therefore must be implemented and monitored as appropriate.

ILO standards set important benchmark for what should and should not be done in the management of labour on employment-intensive works.

It should be noted that, implementation of labour-based works in line with international labour standards may prove costly in terms of energy and money in the short run but will achieve greater success and meat most development objectives in the long term.

Some of the ILO standards based on human rights, good labour policies and practices in employment/ labour intensive programme include the following:

- **Equality:** Men and women should receive equal pay for work of equal value.
- **Freedom from forced labour:** Work or service should not be exacted from any person under the menace of any penalty or under circumstances where the person has not offered himself or herself voluntarily.
- **Freedom of association:** Workers and employers should have the right to establish and join organisations of their own choosing, without previous authorisation.
- **Minimum age:** No person under the age of 15 should be employed or work. No person under the age of 18 should be employed or work in hazardous circumstances.
- **Minimum wages:** Minimum wage should be established for groups of wage earners where, in consultation with employers' and workers' organisations, the competent national authority finds it appropriate.
- **Protection of Wages:** Wages should be paid in money. Where wages are paid partially in the form of allowances in kind, such allowance should be appropriate for the personal use and benefit of the worker and his or her family, and fair value should be attributed to such allowances.
- **Occupational 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 methods of work and express views on the working procedures adopted as they may affect safety and health.
- **Labour profile:** This advocate for the right of people working together to declare themselves as a group composing of different categories of workers. Skilled and Unskilled, able and disabled, youth and the aged among others.
- **Other employment conditions:**
  - o 40-hr week convention
  - o Holiday with pay convention
  - o Termination of employment convention
  - o Workmen compensation (accident) convention
  - o Maternity protection convention
  - o Labour clauses (public contract) convention
  - o Weekly rest convention

Good labour policies and practices in employment intensive programmes are implemented through the following:

- Recruitment
- Setting of wages
- Basis of remuneration
- Remuneration in kind
- Protection of wages
- Attendance
- Labour regulations other than those dealing with wages
- Motivation and discipline
- Management and supervisory training
- safety and health
- Socials Security and Insurance
- Duration and termination of employment
- Rights of association

Welfare Laws (Regulations)

Social Security and Insurance

There are tree ways of introducing minimum levels of social security. These are:

- Prioritising different types of social security
- Setting up types and levels of social security to which workers are entitled
- Arranging social security in the context of existing national programmes.

Importance of Social Security and Insurance in LBRWs

Labour-based technologies are often chosen because of the **benefits they provide in employment, skill development, and conservation of scarce resources and building a sense of community**. For this reason, it is particularly objectionable for a labour-based project to "**cost**" those it aims to benefit by leaving them either temporarily or permanently injured and without source of income. Furthermore, if labour-based projects are to be considered in the "**mainstream**", they should respect the law of the land with regard to coverage by social security programmes. On both of these grounds the issues of social security and insurance are very important.

Social security or insurance cover to be considered in Labour Based Road Works

Highest on the priority list is coverage of workers in case of **accident or death** on the job.

National social security programmes also sometimes make provisions for **pensions**. These programmes very rarely cover temporary labour-based workers. There is generally not much interest amongst workers in the labour-based sector in coverage by pension plans, but this can vary from case to case.

As a rule, programmes are required by law to comply with social security, pension and insurance. **Contracts may also require either that the law is applied or that adequate insurance** coverage is secured for workers where there is no applicable law.

Determining coverage of workers by existing programmes

There may be **sector-wide or nation-wide social security or insurance programmes** that cover people employed in the labour-based sector. Programmes could also cover only **particular job categories**. Programmes may also set limits in coverage linked to the number of hours worked weekly, days worked monthly, or some other similar characteristic.

Those involved in related industry may need to consult with local and industry officials to find out what programmes, whether private or public, may already exist.

What should be done if there is resistance to coverage?

Experience suggests that, labour-based workers, supervisors and managers can resist coverage of various types. This is particularly so **where coverage costs the individual money**. This resistance can occur for a number of reasons. People are:

- Resisting a reduction in take-home pay
- Unaccustomed to the idea of social protection
- Doubtful that benefits will materialise
- Doubtful that accidents can happen

These concerns should be directly addressed and efforts made to remedy them by providing credible guarantees that benefits will materialise and explaining the benefits of coverage.

The International Labour Office has put together a Guide called:

"**Employment Intensive Infrastructure Programmes: Labour Policies and Practices**". It provides information for:

- policy makers
- ministries of labour and employment
- ministries responsible for civil works
- workers' organisations
- employers' organisations
- engineers
- local authorities
- NGO'S
- community based organisations
- donors and financial institutions

Alternative to consider when national systems do not work, or coverage is not effective/sufficient

In the case of risks from accident, and particularly the harm, which could be done by the loss of income earning capacity in the short or long term, effective insurance or social security coverage is very important. All reasonable efforts should be made to produce coverage with benefits at reasonable level.

Rights of association

Issues of concern under this include:

- Basis principles of associative rights
- The benefits which can come from associations of workers and employers
- How associative rights can be put into practice.

Right to association

The right to associate is the freedom people have, as recognised by law, to form organisations of their own choice in order to pursue lawful objectives. These include:

- Co-operatives
- Workers' organisation
- Business co-operation
- Local community organisation
- Employers' organisation
- Chamber of commerce
- Political organisation
- Cultural organisation

Importance of association

The right to associate is the foundation for peoples' efforts to come together to accomplish a particular objective. **Without it, it becomes less possible for the objective they have in mind to be accomplished and the benefits that flow from people joining together are lost**. Practically speaking, the right to organise is exercised by

- Workers in order to act together on matters which affect them,
- Employers in order to act together on matters which affect them
- Community members in order to formalise their productive organisations such as co-operatives or infrastructure construction or maintenance groups, and
- **(Labour-based) contractors** to improve their businesses and have a forum through which to act together on matters which affect them.

In labour-based activities, associations tend to increase efficiency because through them:

- Workers are able to channel ideas for better working conditions or efficiency improvement through their organisations
- Community members are able to stabilise and consolidate improvements made in local living conditions and then move forward to make even more progress
- Contractors can share experiences and improve practices if they are able to form a contractors' or employers' association.

Of course, as will any right, its abuse can also have destructive influences. Educated leaders and members of organisations usually understand where their self-interests lie and manage the activities of their organisation without them becoming destructive.

Promotion of association rights in labour-based programmes

All those concerned with labour-based projects can insist upon the right of association as a matter of principle.

As a practical matter, people must be free to exercise the right. No one should be coerced into exercising his or her right to associate. In order, however, for the benefits of association to be achieved, the right must be exercised in practice.

Therefore, a labour-based policy should include ideas for promoting without coercion exercise of the right to associate. Promotional activities include:

- Disseminating information about the rights and benefits which can be derived from exercising the right to associate,
- Making organisational and contractual arrangements with a view to institutionalising the activities and achievements of associations,
- Training on the technical matters which can be dealt with through associations,
- Better acquainting existing employers' and workers' organisations with labour-based programmes, with the aim for them to extend their organisations to cover the interests of those in the labour-based sector. (Refer to ILO Guide)

H5.2 WORKPLACE SAFETY IN LBRWS

Introduction

Safety in relation to road works means process through which adequate facilities and arrangements for protection of employees, road users and any other persons who may be adversely affected by working operations at the site. It is important therefore for both road workers and users to know causes of accidents at work sites so that precaution is taken against such occurrences during execution of road activities.

Causes of Risks/Accidents at Work Place

There are four main sources of danger to the workers and the public on a road construction site that is open to traffic as:

- **People:** Lack of preparation and information, habit of neglect and fatigue are all factors, which significantly increase risks.
- **Equipment:** Every vehicle on site is a source of danger. This danger is even greater if vehicles are not equipped with signalling and detection systems specific to the type of sites on which they are being used.
- **Jobs:** Some jobs are more dangerous than others are. Despite all organisations efforts, everyone must be aware of the dangers involved in a job or task, proactive and exceptionally vigilant against such dangers at all time.
- **Environment:** the environment of every site is dangerous in a different way. Poor visibility, dense traffic, narrow roadway width and weather are all factors, which make sites more, complicated and contribute to risks.

Others are:

- Lack of awareness of workplace safety issues on the part of employees and employers
- Failure to implement safety policies on the part of the employer and the client.
- Failure to incorporate safety related issues at the design stage of a programme or activity
- Poor signing at the workplace
- Lack of motivation on the part of the workers
- Lack of respect for traffic signs on the part of road users and workers during road works
- Failure to demarcate properly workplace areas for tasks performance

Site safety involves everyone whatever jobs; it is up to all to take the **RIGHT** preventive **ACTION**.

Mainstreaming Workplace Safety and labour Issues in LBRWs

Workplace safety concerns in road improvement cycle shall be considered during preparation and planning, implementation and impact evaluation. Both the stages and activities under which mainstreaming of workplace safety and health concerns take place are described as below.

Planning and Preparation

Under planning and preparation, occupational safety shall be addressed during design, preparation of contract documents, mobilisation and sensitisation, contractor procurement and training. These have been elaborated as below:

Sensitisation and Awareness Raising

There is usually poor workplace safety awareness among the stakeholders (including contractors, workers, district technical staff and politicians among others) in general and in the roads sector in particular. It is therefore imperative that sensitisation and mobilisation is carried out for the different target groups as follows:

Workplace safety issues in road works shall be part of sensitisation and mobilisation campaigns conducted at community and sub-county levels (to target sub-county works or general-purpose committee, members of the communities who are potential workers, sub-county officials and politicians) as part of the community meeting referred to as **Mobilisation Site Meetings** (see the checklist in **Annex 1**). During the meeting, the District Engineering and other staff shall remind the Contractors and their staff including members of the community who are potential labourers about workplace safety issues. Strategies on how to address labour and workplace safety issues shall be part of the discussions.

During road improvement works, the Contractors and workers shall have the opportunity to be sensitised on labour and workplace safety issues during **Mobilisation Site Meetings**. Convened on a monthly basis to monitor progress in road improvement activities and check compliance with crosscutting issues. During such meetings, the District Labour officer, District Engineering and Community Development staff shall ensure that labour and workplace safety issues are presented and discussed as provided for in the Information Sheet and Checklist. The Contractors shall be required to inform the meeting on how they are addressing labour and workplace safety issues.

Contractor Procurement

The contractor procurement process from pre-qualification to tender award shall be sensitive to workplace safety concerns. Pre-qualification of contractors shall favour those who shall demonstrate capability and willingness to address workplace safety issues. The District Engineering and Labour staff shall play a key role in providing technical advice to the Technical Evaluation Committee and the District Tender Board so that the Contractors pre-qualified are sensitive to workplace safety.

During contract procurement, the Tenderers shall be reminded of workplace safety and health issues through **Pre-tender Site Meetings** held prior to the Tenderers preparation tender documents. This means the Tenderers shall go into the bidding process when they are well aware of the workplace issues.

In addition to technical and financial evaluation therefore, Tenderers shall be evaluated in regard to their response to workplace safety related issues and their proposal to address them. The most important is adequate provision for workplace safety issues as an item in the Bill of Quantities by the Tenderer.

Training

Labour and workplace safety sensitisation is already an integral part of the technical training provided at **MELTC**. Labour and workplace safety issues have been provided for in the **MELTC** Curriculum. The implication is that everybody going for training at **MELTC** shall receive training in labour and workplace safety issues in road works. It will be the responsibility of the districts with the advice of the District Engineer to screen and send contractors including district staff (both engineering and non-engineering) and relevant political leaders for training at **MELTC**.

Implementation of Road Improvements and Subsequent Maintenance

The use of labour-based methods is the more reason for providing good labour and workplace safety awareness. This is because use of labour-based methods involves more people in contract works, which requires good working environment as a matter of human rights. Workplace safety shall be made a contractual obligation of Contractors in that special provisions shall be made in the contract administrative documents, especially Conditions of Contract.

Responsibility to Safety at Road Work Sites

The responsibility of ensuring safety at roadwork sites solely lies on the following as described below:

- Client (Management and Supervision)
- Contractor (Management and supervisors)
- Employee (workers)
- Road users and visitors to the site.

Client (Management)

It is the duty of the client to ensure that:

- Safety issues at roadwork site are incorporated at the design stage.
- His representatives monitor effectively the implementation of safety issues by the contractor
- The Contractor is availed safety related regulations in force.

Contractors and contractor Staff

Management has to make sure that:

- Safety issues are incorporated in the contract document. Documentation are sufficient and in accordance with the existing safety regulations
- All workers recruited are sensitised on the various safety issues.
- There is a company policy on the implementation of safety issues that sets achievable standards.
- That workers are provided with protective clothing and any other safety equipment where necessary
- Those supervisors are trained in workplace safety issues and implement.
- He/she submits a labour and safety programme/work plans to the client before commencement of work.

Supervisors (Engineering staff)

Supervisors from District/Contractor have to ensure that:

- He/she understands the District/company's labour and workplace policy implementation statements.
- Safety aspects incorporated in the contract documents are understood and implemented
- Workers use protective gears provided to them correctly (they must utilise the available gear)
- Plant, equipment and tools are in a satisfactory, usable condition
- The appropriate procedures and systems are followed by all concern.
- Site rules for safety, or systems of work are contained in a written method of statement.

H5.3 METHODS OF REDUCING RISKS ON SITES

- **Collective safety:** every site must be clearly indicated so that it is visible from a far and when close. The signalling systems must inform the road users of the presence of a specific danger and convince them of its importance in order take necessary precautions. Signalling must guide users throughout this dangerous transit zone and protect them from any hazards they might encounter.
- **Personal Safety**: everyone working or driving on site must wear safety uniforms and also to be easily seen. Some jobs require additional safety such as helmets, sewing reflector tapes to safety uniforms for top visibility when working at night. (Site workers should see to it that they are easily identified by road users. "**SEE TO BE SEEN**".
- **Behaviour:** Everyone on site must assume responsibility for himself or herself and for the other people.

  Everyone must worry about dangers and work within the zone protected by a suitable signalling system and must warn others about dangers that they might not have considered.

  Safety is a quality factor that District/contractors owe to their customers. A well-signalled site with people wearing uniforms improves safety and corporate image.

  District/Company gives the means to work safely and it is the worker's own life that is at risk. The moto should be "**I am protecting my company by respecting the safety rules**".

  Personnel responsible for the road signing should always ask them selves this question "Will a road user approaching the site from either direction understanding exactly what is happening and what is expected of them"

  For ones own safety and that of colleagues, individual workers should always be alerted to the presence of traffic through the work site or construction plant nearby. Simply put a sign, **SEE AND BE SEEN**.
- **Other ways to Reduce Risks**
  - **Organisation:** Before work starts, the general foreperson and the site engineer should inspect the site and identify all the factors which need to be considered and adopt construction methods to suit the site conditions.
  - **Communications:** Is a powerful safety tool. Keep the crew informed at all times particularly new members, temporary workers and sub-contractors about the risk involved with each site.

    In this way they will understand the dangers and take appropriate action. This information should be confirmed in writing with access plans for jobs.
  - **Safety Training:** Make sure that everyone is given full details about, traffic flow at the site, instructions for execution of the work, and what to do if an accident occurs.

    Instructions must be given to all new shifts coming on, every person who has not worked on a site for more than 21 days, all new recruits, and temporary workers and all sub-contractors.

- **Safety Mindedness:** As no one person can do everything, it rapidly becomes vital to delegate jobs to each crewmember.

  However delegation doesn't mean asking just anyone! You have to take your time, act progressively and clearly explain the approach to use.

  Responsibility tends to make jobs more meaningful. Work executed more conscientiously, fully finished and always includes safety.

POSITIONING OF ROAD SIGNING:

This is the recommended sequence method of installing and removing signs at the site:

- **Road works ahead:** Should be placed first about 60 m well before the works, as is the first to be seen by the driver, so place it.
- **Road narrows ahead:** warns drivers which side of the carriageway is obstructed. Should be placed midway between the first sign and the beginning of the temper of cones guarding the works.
- **Cones and Lamps/ Reflecting tapes:** should be placed in a line to guide traffic past the works and add road danger lamps at night or in poor daytime visibility and bad weather. The length of the temper will depend on how fast the traffic is.
- **Keep left and Keep right signs:** Place it at the beginning and end of the lead in temper of cones/tape.
- **Traffic Barriers:** should show the width of the work site within the coned off area and must face the coming traffic.
- **Pedestrian Barriers:** In case of deep excavations fence off the excavation where pedestrians would normally have access allowing sufficient clearance to prevent them falling into the whole.
- **End Sign:** is placed at the end of road works beyond works that are more than 50 m long. This is necessary if the traffic count is more than 20 vehicles per 3 minutes.

Finally at the end of the completion of the works, the road signing should be removed in the reverse starting with the last to be put.

The main objective of putting road signs for safety at road works can be simply stated:

WARN	-	Road users approaching work
INFORM	-	Of nature/layout of obstructions
GUIDE	-	through the work site
ROAD CLEAR	-	end of work site

Supervision of Works

During physical works, the Engineering and Labour staff shall pay routine and regular visits to the site. It is important that during physical works, the Contractor must ensure the following:

- Apply labour-based methods whenever the character of work allows. For activities that are hazardous and unsafe to physical handling by the labourers, equipment shall be used.
- Provide quality hand tools to workers as appropriate. Consideration shall be made to provide the workers with the tools widely used in the area.
- Provide safe drinking water and good quality food at workplace either in kind or cash. In case meals are to be provided in cash, workers' consent shall be sought.
- Pay workers reasonable wages as agreed and in time. Consideration shall be given to the prevailing market rates and what is reasonable to meet the livelihood needs of the workers.
- Provide protective wear to workers as appropriate (the right protective wear for a particular job)
- Provide first aid kits available at the site all times with a trained person to administer
- Provide separate sanitary facilities for male and female workers

It is the responsibility of the District Engineering and Labour staff to ensure that the above are provided at the work sites as catered for in the Bill of Quantities.

H5.4 MONITORING SITE MEETINGS

The Monitoring Site Meetings shall provide the various stakeholders, the Contractors, workers, Sub-county Works Committees and members of the community a forum where they can raise and discuss issues that affect the successful undertaking of road works including safety and health. The questions that can be asked and discussed at the meeting may include:

- Are workers provided with the right and quality hand tools? If not why and if yes to what extent?
- Are there sanitary facilities at the site? Are they provided separately for men and women?
- Are meals and safe water provided for? If yes, what is the quality and if no, why are they not provided?
- Are workers paid in time?
- Are workers provided with the right protective wear for the jobs they perform?
- Are first aid kits available at the site at all times and who administer it?

Asking these questions will generate discussions and check on the Contractors to fully comply with labour and safety issues.

Monitoring and Reporting

Monitoring activities shall check the extent to which the Contractors are complying with crosscutting issues including labour and safety issues. Monitoring shall be done by Engineering and Labour staff as well as community leaders.

Monitoring mechanisms to be employed shall include but not limited to **Site Visits and Monitoring Site Meetings** (refer to **Annex 4** for details).

Handing Over

Prior to handing over of the improved road, the Labour Officer shall issue a compliance certificate confirming that that the contractor has fully complied with the labour and safety issues as per the conditions of contract. The certificate will be based on the report of the Labour Officer who shall inspect the site before completion of works. Final payment to the contractor shall only be effected after issuance of the certificate.

Section H6

Health and HIV/AIDS

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H6 HEALTH AND HIV/AIDS

H6.1 HEALTH ISSUES ASSOCIATED WITH LBRWS

Introduction

In Labour Based Road Works (**LBRWs**), Occupational health issues can be experienced when undertaking district road works especially in the areas of:

- Routine Maintenance
- Periodic Maintenance
- Rehabilitation
- Spot Repairs

The nature of work involved in **LBRWs** may expose workers to occupational accidents or hazards that usually are major causes of occupational health issues at the workplace.

Occupational accidents: are sudden unplanned, and unintentional occurrences, normally causing bodily harm, or injury. Accidents considered are those that occur during work hours or on the way to and fro the workplace.

Occupational hazards: are factor(s) in work environment, which create a risk of injury or disease and may result in occupational accident or disease.

The objectives of occupational health and safety include among others:

- Ensuring safe and healthy working environment
- Safe and healthy workers
- Reduced accidents and death occurrences
- Reduced compensation costs/expenditure
- Reduced cost/expenditure

It is within the above reasons that attempts are being made to address workplace conditions and environment in the road and transport sector

Causes of health issues (Risks) in LBRWs

Carrying out activities on a construction site involves interaction of people and other aids such as equipment and tools. Under such circumstances accidents are bound to happen resulting into serious occupational health issues like injuries or even death of workers and perhaps may extend to the local communities as well. Causes of these can be Human error, negligence or natural occurrences. This can be elaborated as below.

The major cause of health issues in **LBRWs** is the exclusion of these very sensitive and important issues in the Contract Documents. This has therefore made contractors reluctant to provide for them as necessary. On the other hand, during actual field execution of works, causes of health issues include:

- Engagement of workers in road improvement activities with poor/damaged tools, or wrong tools for a particular and specific work.
- Engagement of workers to use machines and tools for which they have not been trained to use.
- Involvement of workers in activities without appropriate protective wear.
- The exposure of workers to harsh environment such as prolonged sun heat or heavy rain.
- Exposure to difficult working situations such as Quarry sites and thick forests among others.
- Non provision of First Aid Kits (FAKS) and safe drinking water and food to labours by contractors.
- Exposure to excessive noise from equipments e.g. rollers that might affect the hearing ability of workers.
- The exposure of workers to dust and other toxins from petroleum Products during implementation of works.
- Non provision of sanitary shelters for workers at work sites or campsites.
- Lack of informatory signposts indicating that work is in progress.
- Carelessness on the part of workers.
- Forgetfulness on the part of workers on issues explained to them earlier.

Health Precautionary Measures in LBRWs

To be able to address occupational Health issues in **LBRWs** by improving workplace conditions and environment at work sites, it is important to incorporate them in the overall road improvement cycle. Key activities in which health issues have to be incorporated include:

Planning

- Road Inventory and Condition Survey (ADRICS)
- Road Prioritisation and Selection
- Detailed Survey and Design
- Procurement of Contractors

Implementation

- Road Works
- Monitoring and Reporting

It is important to include health issues into Contract Documents. Any deviations from what is reflected in the documents would mean a breach of contract and a penalty against such an act should follow suit. (refer to manual - Workplace and safety - Guidelines for District Engineers).

It is the duty of the contractor, the local leaders, the community and all other stakeholders to ensure that those safety precautions which are remedies to health issues in road works is maintained at site.

Health Precautionary measures or occupational Safety practices therefore would ensures that:

- The workers are protected from injury.
- The tools or equipment are protected from being damaged.
- The finished work is not damaged or wasted.
- The public /community is protected from injury

Table 1-H6 is a tabular presentation of some of the health issues in **LBRWs** mentioned earlier and their possible precautionary measures against them.

TABLE 1-H6: HEALTH ISSUES RELATED TO LBRWS AND POSSIBLE PRECAUTIONARY MEASURES

Occupational Health Issues	PrecautionaryMeasure
• The exclusion of occupational health issues in contract documents.	• Occupational health issues shall be mainstreamed in the road improvement cycle and later included in contract documents to make it obligatory.
• Engagement of workers in road improvement activities with poor/ damaged tools or even wrong tools for a particular and specific work.	• Contractors should provide for their workers the required and quality hand tools for the execution of the specific road activities as necessary.
• Engagement of workers to use machines and tools for which they have not been trained.	• Contractors shall provide on job training to workers on how to handle and use available tools and machinery before engaging them fully in road activities.
• Involvement of workers in activities without appropriate protective wear	• Contractors should provide appropriate protective wear to workers for specific activities. (Gumboots, overalls, helmets, gloves etc.)
• The exposure of workers to harsh environment such as prolonged sun heat or heavy rain.	• Temporary make swift shades shall be erected for purposes of avoiding rain, too much sun rays and shade breast feeding mothers and babies to sleep in.
• Exposure to difficult working situations such as Quarry sites and thick forests among others.	• Site assessment for risks involved and possible accident prevention measures should be done prior to the start of activities.
• Non provision of First Aid Kits (FAKS), safe drinking water and food to labourers by contractors.	• FAKs must be available at all times at site for purposes of minor injuries. • Contractors shall provide safe drinking water and food either in kind or in cash form to their workers and these should be spelt out very clearly in the terms of contract.
• Exposure to excessive noise from equipment that might affect the hearing ability of workers.	• Provision of ear muffs to workers using such equipment
• The exposure of workers to dust and other toxins from petroleum Products during implementation of works.	• Workers handling petroleum products must do so while wearing the right protection gear. Water with a water bowser at least 3 times a day shall control excessive dust.
• Non provision of sanitary shelters for workers at work site or campsites.	• Campsites should have shelters with provision for gender needs taken into consideration.
• Lack of informatory signposts indicating that work is in progress.	• During execution of work especially at a site free to traffic, informatory signposts must be availed so as to lessen the risks of accidents to workers.
• Carelessness and forgetfulness on the part of workers on health issues explained to them earlier.	• Workers must be vigilant and alert at all times for their own safety. They must see to it that they put to use their Personal Protective Equipment (PPE). These include appropriate foot wear, hand gloves , helmet and Gumboots among others.

6.2 HIV/AIDS ISSUES ASSOCIATED WITH LBRWS

Introduction

HIV stands for Human Immuno-deficiency Virus. It is the virus that causes **AIDS**. If some one is **HIV** positive, the person may show no symptoms and will remain healthy for many years. However, no matter how well a person may feel, the virus remains in his /her body and can be transferred to another person. Over the years, the persons immune system weakness, meaning that he/she will be vulnerable to many illnesses (syndrome), which may include tuberculosis, and some cancers, eye, skin and nervous system conditions that can be serious. As a person suffers these illnesses, he/she will later on develop **AIDS** and will suffer frequent attacks of different illnesses.

AIDS stands for Acquired Immune Deficiency Syndrome. This is a stage when an **HIV** infected person begins to suffer many illnesses as result of a weakened immune system as mentioned earlier. At this stage, it may be difficult to engage such a person on heavy road rehabilitation activities. However, this does not mean that, such a person is stigmatised and not given work at all at site. He can do fairly simple tasks that his system can afford. It is important therefore to create awareness to parties involved in road activities exactly what **AIDS** is all about and how it is transmitted.

Modes of HIV/AIDS transmission

All the stakeholders in the road sector and later the community who will constitute the work force during the execution of road activities must be made to know the different ways through which **HIV/AIDS** is transmitted. They include the following:

- Having unprotected vaginal or anal sex (without a condom) with someone who is **HIV** positive.
- Sharing syringes.
- Contaminated medical equipment which has not been properly cleaned
- Being given **HIV** untested infected blood transfusion
- Donor insemination with **HIV** infected semen

Other ways through which **HIV/AIDS** can be transmitted.

a) **Mother to Baby**

- The virus is transmitted to the foetus across the placenta during pregnancy.
- The baby may be infected during childbirth
- A baby may be infected through breast milk.

b) **Children can get HIV from:**

- Receiving infected blood transfusions
- Receiving treatment with unsterile medical equipment such as needles. Syringes or surgical instruments.
- Suffering sexual abuse involving penetrative vaginal or anal sex.

It is of importance for every body there fore, to take precautionary measures against the above listed, modes of **HIV/AIDS** transmission to remain safe from infection.

HIV/AIDS is not transmitted by:

- Shaking hands or hugging
- Tears or sweat
- Sneezing or coughing
- Using other people's cutlery
- Dogs, cats or insects bites
- Kissing or saliva
- Eating from the same plate.

Why mainstream Health and HIV/AIDS in road works

Management of risks, health and safety considerations in road works is a continuous process and it is of paramount importance to the Ministry of Works Housing and Communications operations and activities in its areas of mandate. This calls for the need to regularly identify the hazards and assessing the risks associated with them in the various sub-sectors at large and roads in particular.

Legal Obligations

i) The Constitutional responsibility.

The 1995 constitution of the Republic of Uganda has a number of substantive provisions for safety **HIV/AIDS** and gender integration into activities.

Article 39, creates a right to a clean and healthy environment which is a basic right to every citizen.

ii) The Multi-sectoral Approach by Ministry of Health.

This mainly applies to **HIV/AIDS**. The approach was developed by Ministry of Health with the aim of having **HIV/AIDS** mainstreamed in all development Programmes. This is because of the general realisation that **HIV/AIDS** has got multi-dimensional effect on the whole economy and therefore requires a multidimensional effort towards its eradication.

HIV/AIDS and LBRWs.

The magnitude of negative effects caused by **HIV/AIDS** towards economic growth and development has been very big worldwide. This is attributed to the fact that the most affected are the working population. Because of this fact, in Uganda, the Ministry of Health has made it a requirement through the Multi-sectoral approach, to mainstream **HIV/AIDS** in all development activities, the Road Sector among them. The nature of work entailed in road activities creates direct linkages between **HIV/AIDS** and road works especially in **LBRWs** methods. This can be elaborated as below.

- Labour based methods of road works is that technique in road works that calls for a high degree of use of manual /human labour to execute road activities supported with light equipment such as Pedestrian rollers, tractor towed rollers and tractors among others. Because of the nature of work involved, bringing big numbers of people of different sexes and age groups to work together, chances that their interactions during the course of work in groups developing into sexual relations between men and women is very high. Such **LBRWs** sites there fore provide a breeding place for the spread of **HIV/AIDS** among the workers from the communities.

- **LBRWs** sites are usually very active sites, with people from different social and economic backgrounds providing different services at the site. Classes of people involved include; the contractors, site supervisors, District officials, businessmen and women, food vendors inclusive as well as the road users (the community members). Usually the local communities who are the job seekers are the majority, and usually are the most poor of the classes mentioned. In their quest for jobs or a few extra shillings to meet their expenses, may get involved in sexual favours from the more economically able class at the work sites. Such a class of peoples will only look at the financial gain accruing to them now and not the risks that may be involved. This too, would lead to the spread of **HIV/AIDS** among the participants especially when such involvement is not protected.
- Usually when a road is improved, chances that Truck Drivers buying local produce and supplying other necessities to the local communities, other mobile population like sex workers, groups of business men and job seekers increase in the communities. These categories of people are usually vulnerable to **HIV/AIDS** catch because of the nature of their jobs and, they could also be a transmission source to the local population.

It is against such direct linkages between poverty, **LBRWs**, improved roads and **HIV/AIDS** that there is a need for a wide spread campaing on **HIV/AIDS** and its preventive measures at road construction/ maintenance sites. The target group for training and sensitisation shall be the road workers and those community members at proxy kilometres. This therefore explains the reason why, **HIV/AIDS** has been mainstreamed into the road sectors among other development sectors.

Intervention Measures for HIV/AIDS in LBRWs

Principally, in all activities and operations on the road, the emphasis on handling occupation health and **HIV/AIDS** will seek to:

- Ensure that **HIV/AIDS** is mainstreamed in the road improvement cycle.

When to Mainstream Workplace Safety, Health and HIV/AIDS in LBRWs

Planning and Preparation

Activities under planning and preparation include **ADRICS**, road prioritisation and selection, mobilisation and sensitisation, contract procurement and training. Under planning and preparation, occupational health and safety shall be addressed during design, preparation of contract documents, mobilisation and sensitisation, contractor procurement and training as elaborated below:

Sensitisation and Awareness Raising

Health and **HIV/AIDS** issues in road works should be part of sensitisation and mobilisation campaigns conducted at community and sub-county levels (to target sub-county works or general-purpose committee, members of the communities who are potential workers, sub-county officials and politicians) in those sub-counties where roads works would take place. This can be done through community meetings, radio programmes and display of posters.

HIV/AIDS awareness can also be conducted as part of the community meeting referred to as **Mobilisation Site Meetings**. During the meeting, the District Engineering staff assisted by the Labour staff must remind the Contractors and their staff including members of the community who are potential labourers about occupational health and **HIV/AIDS** issues. Strategies on how to address the health and **HIV/AIDS** issues should be part of the discussions.

During the course of the road improvement works, the Contractors and workers will have the opportunity to be sensitised on workplace safety, health and **HIV/AIDS** issues during **Monitoring Site Meetings** (refer to Information Sheet and Checklist in the **Annex 1**). During such meetings, the District Engineering and Community Development staff must ensure that workplace safety, health and **HIV/AIDS** issues are presented and discussed as provided for in the Information Sheet and Checklist for Monitoring Site Meetings.

The Contractors should be encouraged to inform the meeting on how they are addressing health and **HIV/AIDS** issues.

MELTC is the national labour-based road maintenance and construction training centre for training District Staff, Politicians and Contractors. Contractors going for training at **MELTC** will be sensitised formally as part of contractor training programme. BOQs should take into account the sensitisation meetings/ training to be done on such **HIV/AIDS** issues. In some cases the contractor will hire qualified medical personal to do contract to pay them.

Contractor Procurement

The contractor procurement process from pre-qualification to tender award shall be sensitive to workplace safety, health and **HIV/AIDS** issues. This means the Technical Evaluation Committees and the District Tender Boards being aware of and sensitive to workplace safety, health and **HIV/AIDS** issues. It is highly recommended that the districts send their Technical Evaluation and Tender Board members for training at **MELTC**.

Pre-qualification of contractors should favour those who shall demonstrate capability and willingness to address workplace safety, health and **HIV/AIDS** issues. The Detail Analysis Form (**DAF**) must be checked for sensitivity to workplace safety, health and **HIV/AIDS** issues (**Volume 2 Manual A1**). The District Engineering and Labour staff should play a key role in providing technical advice to the Technical Evaluation Committee and the District Tender Board so that the Contractors pre-qualified are sensitive to workplace safety, health and **HIV/AIDS**.

During contract procurement, the Tenderers shall be reminded of workplace safety, health and **HIV/AIDS** issues through **Pre-tender Site Meetings**. Tenderers shall go into the bidding process when they are well aware of the workplace issues.

In addition to technical and financial evaluation therefore, Tenderers will be evaluated in regard to their response to workplace-related issues and their proposal to address them. The tender evaluation form is designed in such a way that it makes provision for appraisal of workplace safety, health and **HIV/AIDS** (refer to **Volume 2 Manual A1** for samples of tender evaluation forms). The most important is adequate provision for workplace safety, health and **HIV/AIDS** issues as an item in the Bill of Quantities by the Tenderer.

The District Tender Board based on the advice and recommendations provided by the Technical Evaluation Committee will take the final decision as to contract awards.

To ensure that workplace issues are reflected in decision making, the Labour Officer must be co-opted in the Technical Evaluation Committee.

Training

Workplace Safety, Health and **HIV/AIDS** sensitisation is already an integral part of the technical training provided at **MELTC**. **MELTC** is a national institution responsible for all the training related to labour-based road improvement and maintenance of district roads. Workplace safety, health and **HIV/AIDS** have been provided for in the **MELTC** Curriculum under the following training Modules:

- Labour and Workplace Safety
- Health and HIV/AIDS

Mobilisation Site Meeting

During the mobilisation site meeting the Contractors are not simply reminded of their contractual obligations but shall become partners in addressing workplace issues during physical works. During the meeting, there is also need to begin to raise **HIV/AIDS** awareness issues. It is the responsibility of the District Engineering staff to ensure that Mobilization Site Meetings are successfully convened with minutes taken and circulated to the relevant stakeholders for easy follow up in future. (refer to **Annex 1**).

Supervision of Works

During physical works, the Engineering and Labor staff as well as a representative from the District Health Department shall pay routine and regular visits to the site.

It is important that during physical works, the Contractor ensure that **HIV/AIDS** sensitization meetings are organized and conducted, not only for purposes of training on modes of transmission and the dangers of **HIV/AIDS**, but also to provide physical needs such as distribution of condoms and informatory posters among others.

The contractor shall work with persons with expertise in this sector. (e.g. from Sub-county health Units or any Private body that can provide this service.)

Apart from the regular site visits a follow up on the Contractor's compliance in providing for the above, Monitoring Site Meetings shall be held on a regular basis.

H6.3 MONITORING, REPORTING AND IMPACT EVALUATION

Monitoring Site Meetings

Monitoring Site Meetings shall be convened regularly, preferably on a monthly basis as a means to following the extent to which Contractors are meeting their contractual obligations in complying with cross cutting issues, health and **HIV/AIDS** issues inclusive. The Monitoring Site Meetings shall provide the various stakeholders: the Contractors, workers, Sub-county Works Committees and members of the community a forum where they can raise and discuss issues that affect the successful undertaking of road works including safety, health and **HIV/AIDS**. The questions that can be asked and discussed at the meeting would include:

- To what extent are workers aware/ informed about **HIV/AIDS**?
- What programs and practices already exist in their communities against the spread of **HIV/AIDS**?
- What do workers and the community as a whole think and feel about the current approach to **HIV/AIDS** in their communities.
- What do the community members think could be done differently for greater outreach and better understanding of **HIV/AIDS** in their community.

(Questions on the other cross cutting issues shall follow during such meetings)

- Are there sanitary facilities at the site? Are they provided separately for men and women?
- Are meals and safe water provided for? If yes, what is the quality and if no, why are they not provided?
- Are workers provided with the right and quality hand tools? If not why and if yes to what extent?
- Are workers paid in time?
- Are workers provided with the right protective wear for the jobs they perform?
- Are first aid kits available at the site at all times and who administer it?

Asking these questions will generate discussions and check on the Contractors to fully comply with occupational health and **HIV/AIDS** issues. In all cases, the District Engineering and Labour staff should attend and provide guidance in the discussions.

Monitoring mechanisms to be employed shall include but not limited to **Site Visits and Monitoring Site Meetings** (refer to **Annex 1** on meetings for details). Site Visits shall be done on a monthly basis to physically check on progress on implementation of road works while directly observing Contractor's compliance with safety, health and **HIV/AIDS** issues. Monitoring Site Meetings shall precede Site Visits. Minutes of the Monitoring Site Meetings shall be kept by one of the Engineering staff, produced and circulated accordingly to the relevant persons.

The labour staff, members of Sub-county Works Committee, contractor and their staff, representative workers' and members of the community shall attend the meetings among others. Apart from the general discussions on crosscutting issues, specific focus shall be on workplace safety, health and **HIV/AIDS** issues, especially the extent of compliance by contractor.

In order for the relevant departments in the district to follow the process, monthly reports shall be prepared. The reports will elaborate on the extent to which the contractor is addressing safety, health and **HIV/AIDS** issues. At the sub-county level, it will be the Road Inspectors and the Community Development Assistants with the responsibility of the reports. They will submit their reports to the District Engineer and the Community Development Officer respectively who shall be responsible to prepare and distribute the reports to the relevant offices in the district.

Handing Over

Prior to handing over of the road works, the Labour Officer will issue a compliance certificate confirming that the contractor has fully complied with the health and safety issues as per the conditions of contract. The certificate will be based on the report of the Labour Officer who will inspect the site before completion of works. Final payment to the contractor shall only be effected after issuance of the certificate (refer to Workplace Safety, Health and **HIV/AIDS** Compliance Monitoring and Evaluation Form in **Annex 4**)

Impact Evaluation

Data collected from the monthly **HIV/AIDS** sensitisation meetings and surveys shall be used for impact evaluation. The Community Development Assistants and Labour staff shall collect post-road works data on the impact of work situation on the health and safety of workers (Refer to Impact Evaluation Forms in Annex for details).

Section H7

Community Participation

Section H7
Community Participation

H7 COMMUNITY PARTICIPATION

Definition

Community Participation is derived from two words, "**Community**" and "**Participation**".

By definition, "**Community**" means:

- A group of people of different generations, homesteads, different social backgrounds living under a similar environment and a defined geographical location and administration unit. For example:
    - o People of different clans, tribes, races, and Nationalities.
    - o People of different social backgrounds e.g. Religion, educational and economic status.

In the context of road works, a community would refer to road users who live near or along the road comprising of:

- Community leaders
- Tax payers
- Men, women and children
- The elderly, youths and Persons with Disabilities (PWDs)
- Literate and illiterate

In road activities, we rate this community as the major beneficiaries of a well-maintained road.

Participation

Participation on the other hand is the physical, moral and economic involvement of people in a programme or activity. It includes involvement in the planning, implementation, monitoring and evaluation process of the road improvement program.

H7.1 IMPORTANCE OF COMMUNITY PARTICIPATION IN LABOUR BASED ROAD WORKS

In the recent years, there has been increased advocacy for Community Participation in development Programs in their area.

The decentralisation Policy of Uganda also calls for grass root participation in development activities with the insight of bringing services nearer to people, and to increase benefits from these services to the rightful beneficiaries.

Community participation and the reinforcement tools used tend to increase the sustainability factor of a program or project. Capacity within the community is built through their participation to implement and sustain a project. The sense of ownership developed usually leads to a greater impact of program interventions.

Like wise, in the road sector, community participation is important at all stages and processes in a road improvement cycle. This is because participation allows communities to appreciate road activities, develop a sense of ownership and later on protect roads.

Advantages of involving the community in Road activities

Benefits include:

- It leads to a greater understanding of a programme by the local population.
- It gets the communities to accepting to be involved in programme activities (in our case road works)
- It helps to create the sense of ownership of a project/programme within the community leding them to protect the roads and road furniture
- Leads to the transfer of elementary technical skills to the local communities(capacity building)
- Value for money is achieved
- Team spirit is developed within the communities (team work during participation tends to unite the communities)
- Improved social and economic status of the Villages as participants gain through employment and services provided

H7.2 HINDERANCES TO COMMUNITY PARTICIPATION IN ROAD ACTIVITIES

Possible hindrances to community participation include:

- Poor mobilisation for participation in road activities
- Negative attitudes towards road programmes e.g. cultural bias and land ownership issues
- Poor understanding of programme/project concept
- Selfish aims guided by profit maximisation by contractors and other stakeholders
- Corrupt tendencies and lack of transparency

Process to community Involvement in Road Improvement.

A starting point to achieving higher levels of community participation in any programme is the ability to design appropriate tools and methods of mobilisation and sensitisation of communities about a prospective programme.

In the road improvement cycle, community involvement would be required during:

- Planning and preparation
- Road selection and prioritisation
- Implementation of works
- Monitoring and Evaluation

(Refer *to Processes in the road improvement cycle in Gender Guidelines for District Engineers.)*

In all the above processes, community participation shall start with mobilisation the sub-county head quarters, followed by Parishes and then villages.

Mobilisation strategies for community participation shall therefore take these stages as elaborated below.

1. The entry point of community mobilisation shall be the Sub-county head quarters where arrangements with the sub-county shall be made to meet local leaders from both the Villages and parishes. A convenient date for the meeting shall then be set. The purpose of this meeting will be:
   - Introduction of program activities, its purpose, and who would be involved in the process.(Note that this kind of introduction at sub-county level will depend on what activity is programmed or intended for execution at that time e.g. **ADRICS**, mobilisation, recruitment, monitoring and maintenance issues among others)
   - To introduce the contractors and perhaps the district officials to the sub-county Administration (the works committee in particular). Who have to play a monitoring role during implementation.
   - To explain to sub-county Officials the mode of operation, the target group for hire as road employees. (Emphasis to be put on, at least 30% Women's participation on the workforce not restricted to traditional roles but the other activities involved in road works, youth and Persons with Disabilities as special cases.)

- Time frame that the Contractor expects to keep each hired worker on job for purposes of maintaining a constant workforce not to affect the work schedule.
- To explain the Mode of payment (amount for each category of workers and payment). Basing on what is stated in his contract document. These wage amounts should not vary so much from what the community would have proposed during Pretender site meetings since it is the basis on which contractors include in their bid documents.
- And, to invite the local leadership, LC I, II and III representatives, works committee members and councilors from the communities to get them involved in the mobilization of their people for, community mobilization and recruitment meetings. The date and Venue for each activity shall be set in this particular sub-county meeting for consistency in the mobilization process by the community mobilizers.

Note: Appropriate mobilization strategies effective to all target groups should be used e.g. announcements at market places, floats in busy areas such as sub-county notice boards, tree trunks along roads and at health units notice boards. Emphasis shall be put on women's participation. They should be encouraged to get involved by mobilizers.

2. The second meeting will be for the general community members for sensitising them and making them aware of the availability of work and also to:
   - Repeat issues in (1 above) to the local communities for purposes of consistency.
   - Confirm the issues raised during the pretender meetings if they still hold e.g. wage rates, issues on provision of meals and safe drinking water, availability of local construction materials mentioned in the pretender meetings, and water sources for construction activities, etc. (*Look at the checklist for mobilization meetings*)
   - Talk to community members especially men to allow their wives to come for work.
   - To allow community members ask questions or seek clarity on certain issues.
3. The actual recruitment process will be as follows.
   - Priority will be given those interested sub-county community members settled between 2 to 3 kilometers along the road to be worked. (*i.e. because it is still a walkable distance to a work site*)
   - Recruitment will be done in a convenient public venue in the presence of a representative from the contracting firm, local leadership especially local council one chairpersons and at least one sub-county works committee member who will be witnesses to the process. They will also confirm if issues presented to the community are the same with that discussed earlier with sub-county officials. They will sign the recruitment form or book as witnesses to the process. (See attached **Format V**)

Note: The format provides for details such as Road link name, information about individual workers like name, age, sex, village and parish for each worker, as well as space for workers signature. Information such as name, age and sex will be transferred to the muster roll that will reflect the number of days each worker will have worked. Muster roll information will be the basis on which a pay roll is made. It is proposed that copies of these three forms/books be made available to any stakeholder who wishes to see them while on a monitoring visit.

- Only those community members interested to work for a given period of time should be taken as workers so as not to affect the output due to fluctuations in numbers of workers.
- A secret ballot system should always be used to select the required number of workers from the masses who turn up for recruitment. At every one time at least 30% of the workforce should be women. Women should pick their ballot separately. In the selection process, the number of ballots with Yes should correspond to the required number of workers to be recruited.
- All the people recruited should sign or thumb print the recruitment book/ form to show their commitment to the work. This will also act as a contract between the Contractor and community workers. A copy of this recruitment list shall be kept at the sub-county office by a local leader or works committee member to whom reference will be made if there is need. (See attached format **Annex 5**).

Annex 1
Site Meetings

- Explain terms and conditions of employment
  - mode of payment (amount to be paid for each categories of workers and after how long.) asing on what is stated in the Conditions of Contract document, the wage amounts should not vary so much from what the community would have proposed during Pre-tender Site Meetings since it is the basis on which the contractors prepare their bills in the bid documents.
  - Provision of clean drinking water and meals at the site
  - Provision of First Aid Kit
  - Provision of quality hand tools, etc....
- Present and agree on any revised workplan for execution of works.
- Other issues/matters as the Meeting find appropriate

ANNEX 1

MONITORING SITE MEETING

Meeting Information Sheet and Checklist

Preamble

Following the commencement of road works by the Contractor, Monitoring Site Meetings shall be held on a monthly basis. These shall be attended by all the relevant stakeholders to ascertain whether the Contractor is carrying out his/her work in line with gender, environment and workplace health and safety issues contained in the contract documents.

The Monitoring Site Meeting shall be attended by the following:

- Client's representative
- Contractor's representative
- Workers' representative (male and female representation)
- Members of the sub-county Works Committee
- Representatives of the community including special interest groups such as women, youth and persons with disabilities
- Representatives of the district and sub-county community development, environment and labour staff
- Representative(s) of the Donor Agency/NGO where funding source for the works originates therefrom

Minutes of the meeting shall be taken by the client's representative who shall produce and distribute to all the relevant stakeholders. Failure to organise and participate in Monitoring Site Meetings may result in poor communication between the contractor and the communities in which road works would be taking place. The client and the donor agency/NGO providing funds for works will bear no responsibility whatsoever in the event that this leads to the cancellation of contract.

Checklist

The following checklist of activities, to be undertaken during the Monitoring Site Meeting, is for guidance only and may not be fully inclusive.

- Meet with members of the local communities and sub-county stakeholders as a precursor to maintaining good working relationship. The meeting will follow up on mutual obligations by the contractor to the community and by the community to the contractor, including issues relating to gender sensitivity, environment conservation, labour and workplace safety health issues including HIV/AIDS prevention as agreed in Pre-Tender and Mobilisation Site Meetings
- Follow up on availability of materials approved by the Client for fill, surfacing, aggregate, sand, water, etc. and find out whether the Contractor is getting any problem in accessing these materials
- Revisit security issues related to the Contractor's property and all those workers employed from the local communities

- Confirm the availability, location of and condition of access to sources of materials approved by the Client for fill, surfacing, aggregate, sand, water, etc. and agree with representatives of the local communities modalities for accessing these materials and the cost if any thereof
- Locate and acquire storage facilities in the community including the costs involved
- Agree on any measures necessary to ensure security of the Contractor's property and all those workers employed from the local communities
- Other issues/matters as the Meeting find appropriate
- To clarify the mode of operation such as work methods (task allocation and rates, working hours).
- To explain the target group eligible for employment. In all cases, it must be stressed that, both men and women are eligible for employment. Explain the likely application of 50% quota system in the recruitment to allow for a ratio of 1 **:** 1 of women **:** men or where this is not achievable, at least 30% of the labour force should be women. Emphasise that women's participation should not be restricted to only work that is traditionally associated with women but that it should include supervisory roles and other otherwise "manly" work. Youth and Persons with Disabilities should also be considered as special cases.
- Discuss the labour mobilisation strategy and recruitment method for both male and female Provide the local leaders with the Standard Notice of Recruitment (SNR) for display at public places in their respective communities. In this case, local leaders shall include LC officials, officials of community and women groups, church and youth leaders among others. Standard notices shall be posted to public places such as schools, announcements at market places, trading centres and road junctions, floats in busy such as sub-county notice boards, tree trunks along roads and at health units notice boards among others.

MOBILISATION SITE MEETING

Meeting Information Sheet and Checklist

Preamble

Following the award of tender/procurement of the contract by the client to the pre-qualified contractor, all the relevant stakeholders shall attend a Mobilisation Site Meeting to confirm what was discussed during Pre-Tender Site Meeting, and to mobilise the required resources for implementation of works.

The Mobilisation Site Meeting shall be attended by the following:

- Client's representative
- Contractor
- Members of the sub-county Works Committee
- Representatives of the community including special interest groups such as women, youth and persons with disabilities
- Representatives of the district and sub-county community development, environment and labour staff
- Representative(s) of the Donor Agency/NGO where funding source for the works originates therefrom

The client's representative shall ensure that minutes are duly taken and produced during and after the meeting respectively, and distributed to all the relevant stakeholders. Failure by the Contractor to participate in Mobilisation Site meetings and other subsequent meetings may result in poor communication between the contractor and the communities in which road works would be taking place. The client and the donor agency/NGO providing funds for works will bear no responsibility whatsoever in the event that this leads to the cancellation of contract.

Checklist

The following checklist of activities, to be undertaken during the Mobilisation Site Meeting, is for guidance only and may not be fully inclusive.

- Meet with members of the local communities and sub-county stakeholders as a precursor to development of good working relationship. The meeting will discuss and confirm among others mutual obligations by the contractor to the community and by the community to the contractor, including issues relating to gender sensitivity, environment conservation, workplace health and safety issues including HIV/AIDS prevention
- Presentation and discussion of the work plan
- Confirm locations for site camp, and other facilities including latrines, waste disposal etc.
- Discuss the labour mobilisation strategy and recruitment method for both male and female, working conditions, working hours, salary structure including minimum wage and frequency of payment (Clauses 9 and 50 of Conditions of Contract and Clause 32 of Contract Data)

Annex 2

Gender Compliance Monitoring and Evaluation Form

Ministry of Works, Housing and Communications
District Road Works

GENDER COMPLIANCE MONITORING AND EVALUATION FORM

1. Background Information:

(i) Name of contractor: ....

(ii) Contract identification: ....

(iii) Location: ....

(iv) Total distance: ....

2. Nature and extent of work:

....

....

....

....

....

3. Gender Concerns:

(i) Access to information on employment opportunities by male and female members of the communities

	Good	Fair	Poor
Male	Fair		
Female	Fair		

(ii) Recruitment process (fairness to male and female members of the community)

	Fair	Unfair
Male	Fair	
Female	Fair	

(iii) Number of workers employed and working

	Nos.
Male	
Female	

ANNEX 2

(iv) Number of workers employed in different positions

Position	Male	Female	Total
Managing Director			
Site Agent			
Foreperson			
Assistant Forepersons			
Headperson			
Site Clerk			
Accountant			
Store Keeper			
Others			

(v) Number of workers undertaking different tasks

Task	Male	Female	Total

(vi) Equal payment of male and female workers (Yes/No)

Elaborate:

....

....

....

....

(vii) Working system in use (daily payment/task rate/piece rate)

Elaborate:

....

....

....

....

(viii) Flexibility in working time (Yes/No)

Elaborate:

....

....

....

(ix) Workers recruitment:

	Male	**Female**	**Total**
From within			
From outside			
Total			

Elaborate:

....

....

....

(x) Provision of special facilities for male and female workers:

Facility	**Male / Female**	**Remarks**

(xi) Provision of on-the-job training:

Facility	Male / Female	Remarks

(xii) Community participating in decision-making:

Facility	Male / Female	Remarks

4. Innovations at coming up with measures to address gender concerns

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5. Conformity to existing policies and existing legal framework

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6. General Comments/Recommendations

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Name of Monitoring/Evaluation Personnel: ....

Designation: ....

Signature/Date: ....

Annex 3

Environmental Compliance Monitoring and Evaluation Form

Ministry of Works, Housing and Communications
District Road Works

ENVIRONMENTAL COMPLIANCE MONITORING AND EVALUATION FORM

1. Back ground information:

(i) Name of contractor:……………………………..........…………….

(ii) Contract Identification…………………………..........……………..

(iii) Location:…………………………………..........……………………

(iv) Total Distance (km):……………………………..........…………….

(v) Distance (km) monitored/evaluated……………..........……………

2. Nature and extent of work:

………

………

………

………

3. Significant environmental concerns:

(i) Risk to protected areas (Forest, wildlife reserve, heritage site).

None:…………………………………………………………………........………

Significant:………………………………………………….........……………

Highly significant……………....……..(Specify)…………………....………...

……………………………………………........…………………………...

(ii) Impact on Wetland Ecology:

None:…………………………………………..........……………………

Significant…………………………………………..........…………………

Highly significant…………....……….(Specify)………………....……………

……………………………………………........………………………………

(iii) Impact on domestic Water Supply.

None:……………………………………………………………………………………

Significant:………………………………………………………………………………...

Highly significant…………...……..(specify)……………………………..………..

…………………………………………………………………………………………

(iv) Changes in air quality due to vehicle emissions and dust.

None :………………………………………………………………………………….

Significant……………………………………………………………………………..

Highly significant………..........……(Specify)………...…………………………..

…………………………………………………………………………………………

(v) Increased run off and changes in drainage pattern.

None:…………………………………………………………………………………….

Significant:………………………………………………………………………………

Highly significant…………...…...…(Specify)…………………………….………….

……………………………………………………………………………………………...

(vi) Changes in soil stability and erosion

None:………………………………………………………………………………………

Significant:………………………………………………………………………………

Highly significant……………...…..(Specify)………....………………….…………

……………………………………..………………………......………………………

(vii) Changes in land use pattern and intensification of land use.

None:…………………………………………………………………………… ….….

Significant……………………………………………………………………………..

Highly significant……………….......(Specify)……………………......……………

……………………………………………………………………………………………

(viii) Human Population impact (increased density, congesting, relocation?

None:……………………………………………………………..…………………….

Significant:………………………………………………………………………………

Highly significant…………..……….(Specify)…….................……………………

……………………………………………………………………………………………

ANNEX 3

(ix) Effects of working environment on workers health.

None:……………………………………………………………………………….

Significant:……………………………………………………………………….

Highly significant……………………………(Specify)……………………..

…………………………………………………………………………………….

(x) Traffic Accidents.

None:……………………………………………………………………………….

Significant:……………………………………………………………………….

Highly significant……………………………(Specify)……………………..

…………………………………………………………………………………….

(xi) Public health impacts.

None:……………………………………………………………………………….

Significant:……………………………………………………………………….

Highly significant……………………………(Specify)……………………..

…………………………………………………………………………………….

(xii) Social disruptions.

None:……………………………………………………………………………….

Significant:……………………………………………………………………….

Highly significant……………………………(specify)……………………..

(xiii) Depletion of forest, fauna, other natural resources.

None:……………………………………………………………………………….

Significant:……………………………………………………………………….

Highly significant……………………………(specify)……………………..

…………………………………………………………………………………….

4. Mitigation Measures Applied

(I). Involvement of rural communities (Poor, Fair, Good, Very good)

(ii) Erosion and sedimentation (Drainage Channel protection). (Poor, Fair, Good, Very good)

(iii) Restoration of borrow pits: (Poor, Fair, Good, Very good)

(iv) Destruction of vegetation and soil.

Harvesting of vegetation (None, Significant, Highly significant)

Site restoration (None, Significant, Highly significant)

ANNEX 3

(v) Disruption of biodiversity: (None, significant, highly significant)

Specify……………………………………………………………………

(vi) Cross Drainage (Poor, Fair, Good, Very Good).

(vii) Health Hazard: Dust control (Poor, Fair, Good, Very Good).

(viii) Erosion of land receiving concentrated outflow (None, Significant, Highly significant)

Specify:…………………………………………………………………

(ix) Conformity to existing policy and legal framework (Poor, Fair, Good, Very Good).

(x) Conformity to EMAP (Poor, Fair, Good, Very Good).

(xi) Conformity to environmental standards (Poor, Fair, Good, Very Good).

5. General comments/Recommendations

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Name of monitoring/Evaluation

Personnel:……………………………………………………………………

Designation:…………………………………………………………………

Signature:……………………………………………………………………

Date:…………………………………………………………………………

ANNEX 3

Annex 4
Workplace Safety and Health Compliance Monitoring and Evaluation Form

Ministry of Works, Housing and Communications
District Road Works

WORKPLACE SAFETY AND HEALTH COMPLIANCE MONITORING AND EVALUATION FORM

1. Background Information:

(i) Name of contractor: ....

(ii) Contract identification: ....

(iii) Location: ....

(iv) Total distance: ....

2. Nature and extent of work:

....

....

....

....

....

3. Workplace Safety and Health including HIV/AIDS Concerns:

(i) Availability and quality of hand tools

Type of Hand Tools Provided	No. in Good Cond.	No. in Poor Cond.	Total

(ii) Provision of drinking water at site: Yes/No (tick as appropriate and give source)

(iii) Provision of meals at site (tick as appropriate)

Meals provided in kind	
Meals provided in cash (how much?)	
Meals not provided at all	

ANNEX 4

(iv) Number of accidents at site

Nature	Male	Female	Total	Action Taken

(v) Availability and use of First Aid Kits (FAKs)

Availability (observe) Yes/No

(vi) Number of People who used FAKs during the month

Males	
Females	
Total	

(vii) Provision of sanitary facilities for men and women (tick as appropriate)

Type of sanitary facility	Men	Women

(viii) Payments; Amount payable per day in UGX (compare with amounts in contract document)

Category	Male	Female	Remarks
Skilled			
Semi-skilled			
Unskilled			

(ix) Timely payment of workers (after how many days from end of work period interval?)

....

(x) Provision of protective wear to workers

Nature of work	Protective Wear Required	No. of Workers Involved		No. of Workers with Protective Wear	
		Male	Female	Male	Female

(xi) Observe availability of road signs installed at the site and gender sensitivity of language used

4. HIV/AIDS Awareness

(i) Awareness of transmission and prevention*

Awareness Levels	Workers		Community Members	
	Male	Female	Male	Female
Awareness of how HIV is transmitted				
Awareness of how HIV is transmission can be prevented				

NB. Express above numbers out of every 10 people

(ii) Number of HIV/AIDS sensitisation site meetings held

(iii) Number of condoms distributed

5. Innovations at coming up with measures to address workplace safety and Health concerns

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ANNEX 4

6. Conformity to existing policies, legal framework and workplace safety/health issues in the condition if contract

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....

7. What has been the impact of Road improvement activities on the health and safety of the road workers and the community at large.

....

....

....

....

8. General Comments/Recommendations

....

....

....

....

Name of Monitoring/Evaluation Personnel: ....

Designation: ....

Signature/Date: ....

Annex 5
Labour Recruitement Form

LABOUR RECRUIMENT FORM

Name of Road link…………..........………

Contract Number……………………........…..

Sub-county and District………....………

No.	Name	Age	Sex		Village	Parish	Signature
			F	M			

Signature	Signature	Signature
Contractor Representative	Local leader(LCI)	S/C works committee member
…………………………	………………...….	……………………….....……
Date……………………	Date……….……	Date………………………

Annex 6
Weekly Muster Roll

WEEKLY MUSTER ROLL

Name of Road link…………………..

Contract Number…………………..

Sub-county and District…………….

No.	Name	Sex	MON	TUE	WED	THU	FRI	SAT	No. of Days worked	Signature and Date

- *The Numbers and names in the muster roll must follow as in the recruitment form.*
- *The technical person supervising site works on a daily basis will manage the muster roll.*
- *Labourers will sign the muster roll against their names at the end of every week in acceptance to the number of days reflected on the muster roll if at all it matches the number of days they have worked.*

Annex 7
List of References

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8. Labour Based Roadworks Technical Manual Volume 1 *(Tanzania)*

9. *Highway and Traffic Engineering in Developing Countries.*
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10. Road Maintenance and Regravelling (Romar) Using Labour-Based Methods Handbook
    (Claes-Axel Anderson, Andreas Beusch and Derek Miles).