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Preparation of a Design Manual
For
Low Volume Roads in South Sudan

3rd TWG Meeting and Workshop

October 2012

UNOPS
SOUTH SUDAN OPERATIONS CENTRE

This project was funded by the Africa Community Access Programme (AFCAP) which promotes safe and sustainable access to markets, healthcare, education, employment and social and political networks for rural communities in Africa.

Launched in June 2008 and managed by Crown Agents, the five year-long, UK government (DFID) funded project, supports research and knowledge sharing between participating countries to enhance the uptake of low cost, proven solutions for rural access that maximise the use of local resources.

The programme is currently active in Ethiopia, Kenya, Ghana, Malawi, Mozambique, Tanzania, Zambia, South Africa, Democratic Republic of Congo and South Sudan and is developing relationships with a number of other countries and regional organisations across Africa.

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PROJECT ABBREVIATIONS & ACRONYMS

CSIR	Council for Scientific and Industrial Research (South Africa)
DBM	Dry Bound Macadam
DCP	Dynamic Cone Penetrometer
DfID	Department for International Development
EDCs	Economically emerging and Developing Countries
EOD	Environmentally Optimised Design
ERA	Ethiopian Road Authority
esa	equivalent standard axles
GoSS	Government of South Sudan
HQ	Headquarters
ILO	International Labour Organisation
Km	kilometre
LVR	Low Volume Road
m	metre(s)
mm	Millimetre(s)
MAF	Ministry of Agriculture and Forestry
MPI	Ministry of Physical Infrastructure
MRB	Ministry of Roads and Bridges
ORN	Overseas Road Note
PIARC	World Road Association
QA	Quality Assurance
Ref.	Reference
SS	South Sudan
ToR	Terms of Reference
UNOPS	United Nations Office for Project Services
UKAID	Development assistance provided by the UK Department for International Development
USAID	United States Agency for International Development
VOCs	Vehicle Operating Costs
WLC	Whole Life Costs

Preparation of a Design Manual for Low Volume Roads in South Sudan

FIRST REVIEW REPORT

1 Introduction

In line with the key programme stages identified in the Inception Report this document presents a summary of the 3rd TWG Meeting/Workshop and associated discussions held at Juba on 9th October 2012; Table 1. This document will enable members of the Technical Working Group (TWG) and other key stakeholders to review progress; comment on the prosed SSLVR Manual; and to suggest amendments and additional inclusions.

Chapter 2 outlines the workshop proceedings; Chapter 3 presents the key discussion points and Chapter 4 presents a summary and key recommendations. Appendix A presents a list of the participants of the workshop and Appendix B contains the presentations made.

Table 1: Workshop Agenda

South Sudan Low Volume Roads Manual Third Technical Working Group Meeting and Workshop	
1. Welcome and Meeting Objectives	Chairman of TWG
2. Introduction	UNOPS & AFCAP
3. Review of Progress	Project Team Leader (JRC)
4. Presentation of Volume I Draft Chapters:	JRC/RCP
5. Discussion of Issues Arising from Volume 1 Draft	
6. Presentation of Volume 2: Low Cost Structures	RCP/FG
7. Discussion of Issues Arising from Volume 2	
8. Presentation of Volume 3: - Maintenance	RCP
9. Discussion of Issues Arising from Volume 3 Draft	
10. Future Programme	UNOPS & Project Team leader
11. Manual Ownership	
12. Dissemination Programme	
13. Recommendations for Additional Technical Guidance	
14. Summary and Recommendations	Chairman TWG
JRC: Dr J R Cook RCP: Rob Petts FG: Fergus Gleeson	

2 Current Status and Content of the Manual

The status of the SS LVR Manual project was summarised by JRC as follows;

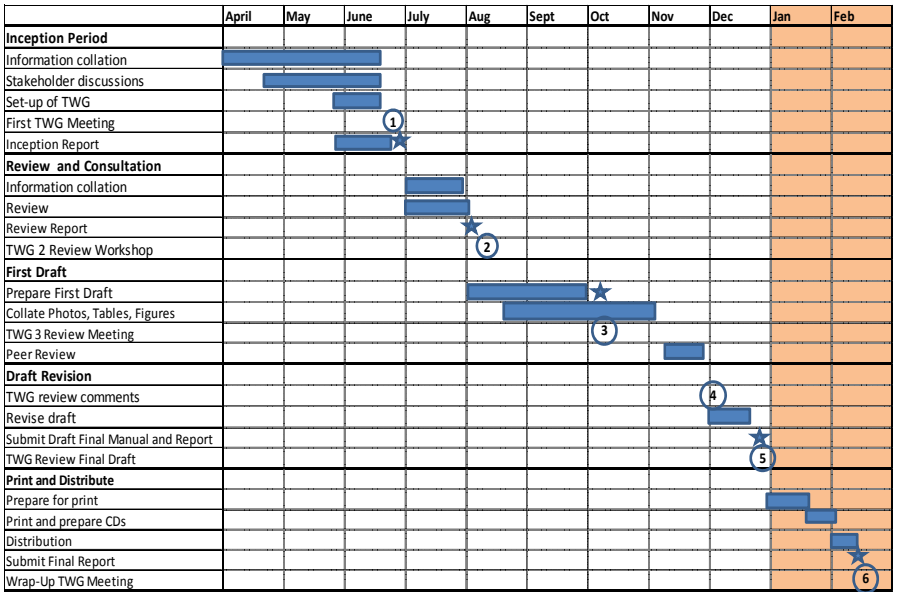
- Inception report √
- LVR Manual Structure √
- Review of Ethiopian Manual √
- Text conversion to WORD √
- File transfer system √
- Draft volume 1 main text √
- Draft volume 2 √
- Draft volume 3 √

JRC indicated that there had been significant challenges in bringing the manual to this First Draft stage:

1. Transferring the ERA Manual from pdf format to WORD text using ADOBE 10 has been undertaken but with significant difficulty caused by "hidden" formats and codes, particularly in tables.
2. Some figures still require re-drawing.
3. The final solution adopted for most of the documents was to leave the ERA Manual in an uncorrected WORD format and extract only those sections that were needed into a blank pre-formatted South Sudan document.
4. It has become increasingly more evident that there is a significant difference between the road environments of S Sudan and Ethiopia that is having an impact on the focus and relative emphasis of key design approaches. Key differences exist for example with regard to: terrain models; climate; hydrology; traffic and its forecasting and the contracting regime

As a consequence of the above JRC proposed a revision of the project programme that envisaged a completion by the end of February 2013. Following some discussion on the dates for upcoming TWG meetings the programme shown in Figure 1 was agreed on an interim basis subject to agreement by AFCAP.

Figure 1 Proposed Revised Programme



This programme takes into account the following actions that still require completion:

- Rationalisation of text between chapters/volumes
- Fill-in some gaps in main text
- Complete Appendices
- Edit figures, some tables
- Insert plates
- Peer review
- Edit-in peer review comments
- Final overall edit and preparation for printing
- Print and prepare DVDs
- Dissemination

JRC and RCP then presented the contents of the 3 draft volumes of the Manual, including the drafts by FG who was unable to attend the Workshop. JRC and RCP highlighted key issues and points for discussion. This presentation is contained in Appendix B to his report.

A number of technical issues were listed as being essential follow-ons to the completion and mainstreaming of the manual:

- Technical Design Specifications,
- Maintenance Specifications,
- Standard Bidding and Contract Documentation,
- Construction Good Practice
- Cost-Benefit Assessment
- Whole-life Costing and Cost model

Mr Francis Abdalla (DD Roads and Bridges, Western Equitoria) gave a presentation on the damage and repair to a road in his area which well-illustrated some typical problems.

3 Key Discussion Points

The following were the main discussion points.

1. There should be a plan to involve private road construction industry representatives in the next stages of the LVR Manual. This was agreed as being a valid point to be followed up.
2. The use and effectiveness of the original ERA LVR in Ethiopia was raised. In fact the ERA Manual was only completed last year so there has as yet been limited time for feedback from practice.
3. The legal standing of the SS LVR document was raised as a key issue. In the experience of the Consultants the official adoption of the manual is an essential step in its mainstreaming as a working document. The general opinion is that the use LVR Manual will become mandatory when it is officially issued by the MRB.
4. More guidance on the geometric design of LVRs at intersections needs to be given. This was agreed.
5. Consideration should be given to making a clearer distinction between the road classification and the road design category tables – perhaps using prefixes (eg N,A, B, C, etc)
6. The Consultants to look at the rationalising the upper limit of LVRs in line with the existing Main Roads Manual which uses a 300ADT limit.
7. Appropriate and effective drainage was raised by several participants as being crucial to the sustainability of LVRs. In low-lying, high water-table areas it is essential that the LVRs are raised on low embankment. The Consultants fully concurred with this view and drainage has been given a major emphasis in the Manual.
8. The appendix relating to traffic assessment has still to be drafted. It needs to needs to provide guidance appropriate for an economy with expected rapid (but geographically varied) growth from a very low base as well as proving guidance on accommodating heavy trucks in appropriate road design.
9. It is essential that as much existing information as possible on road construction materials and their performance is collected together. WFP offered access to their records going back a number of years. At some future stage a national materials mapping and database exercise is required.
10. The local University could play a useful role in collating the above information as well as in other data collection and analysis activities – possibly through the assignment of undergraduate coursework or projects.
11. The issue of damage to road surfacing by cattle drives was raised. It may be that additional strengthening or stone armouring of key sections of roads may be required. The Consultants will consider including a section on this issue.
12. If unsealed earth surfaces are considered for some basic access road links then community involvement may be essential in the deployment of wet weather barriers. This approach has been successfully employed in Kenya.

13. Sources of available information on rainfall records data needs to be identified and the data collated.
14. It was confirmed that the ownership of the manual (and associated documents) should reside with the MRB and that they should look to taking over its management and on-going development as a living document under a research and development umbrella.
15. A programme of dissemination and demonstration should be developed for the mainstreaming of the completed document into working practice at State and County level. This may be by a combination of central or regional workshops and training sessions.
16. There needs to be a period for review and feedback of manuals in the first 1-2 years of practice. This process should be driven by MRB
17. The suggestion was made that a document on LVR Project Management should be considered
18. The maintenance issue was the subject of a great deal of comment and discussion, key points were:
    - They fundamental importance of maintenance
    - Options for implementation
    - Need for maintenance specifications
    - Use of labour methods in maintenance

4 Summary and Recommendations

The South Sudan LVR Manual has been presented as First Draft to the TWG and electronic versions have been made available to all members on CD. A Peer Review draft is now being prepared which will incorporate comments made at, and subsequent to, this workshop, as well additional items, such as the agreed Appendices. Prior to submission for Peer Review the Consultants will review the entire document to rationalise the content between the various Chapters and Volumes to minimise overlap and repetition.

It is anticipated that this Pear Review Draft will be ready by the middle of November. A revised programme has been recommended by the TWG subject to confirmation by AFCAP.

Additional follow-on work has been recommended for consideration by funding agencies by the TWG as being an essential part of the LVR initiative. High on the priority list for this work are Technical Construction and Maintenance Specifications; good practice construction guidelines and research into overcoming the problems of expansive clays.

APPENDIX A

Participants at the 3rd TWG Meeting

9th October 2012

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Appendix B
Presentations

AFCAP

UNOPS

Ministry of Roads and Bridges

Low Volume Roads (LVR) Design Manual for South Sudan

Status Review at First Draft Stage

Dr Jasper Cook
UNOPS LVR Manual Team Leader

UNOPS

Third TWG Meeting and Workshop

This aim of this Workshop is to present the First Draft of the Manual; initiate discussion on some key issues by the Technical Working Group (TWG) and other key stakeholders and to review progress and programme

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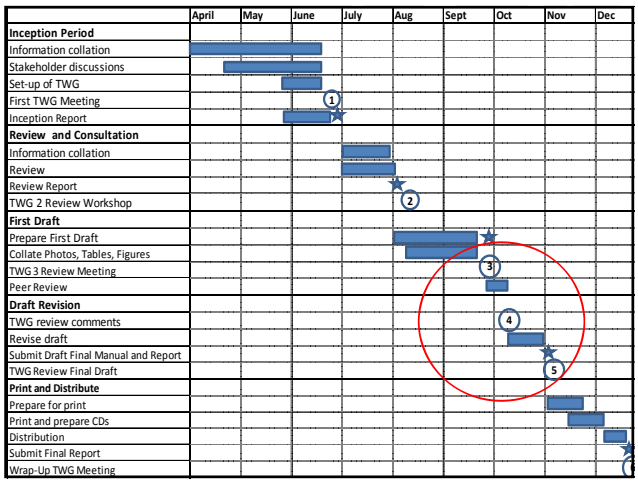
- ❑ Review of Progress — Project Team Leader (J R Cook)
- ❑ Volume I Draft Chapters: — J R Cook/R C Petts
- ❑ Discussion of Issues Arising from Volume 1
- ❑ Volume 2: Low Cost Structures — R C Petts
- ❑ Discussion of Issues Arising from Volume 2
- ❑ Volume 3: - Maintenance — R C Petts
- ❑ Discussion of Issues Arising from Volume 3
- ❑ Future Programme — UNOPS & Project Team leader

UNOPS

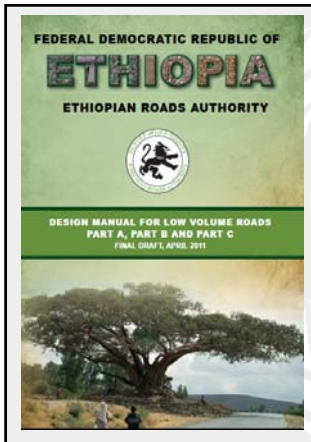
Project Aims

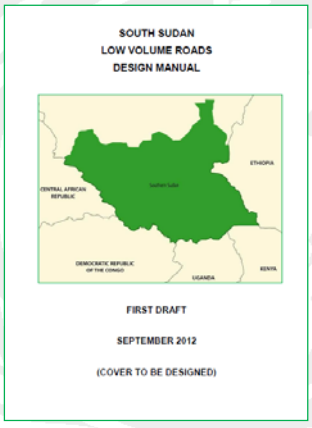
- A design manual and maintenance guidelines appropriate for the specific South Sudan Environment based on modifying the existing Ethiopian LVR Design Manual
- To promote rational, appropriate and affordable implementation of projects providing low volume roads that make appropriate use of local resources and is cost-effective and sustainable.



Progress Summary

- Inception report √
- LVR Manual Structure √
- Review of Ethiopian Manual √
- Text conversion to WORD √
- File transfer system √
- Draft volume 1 main text √
- Draft volume 2 √
- Draft volume 3 √





Some Issues: pdf Conversion

Transferring the ERA Manual from pdf format to WORD text using ADOBE 10 has been undertaken but with some difficulty with “hidden” formats and code, particularly in tables.

Some figures will require re-drawing.

The final solution adopted for most of the documents was to leave the ERA Manual in an uncorrected WORD format and extract only those sections we needed into a blank formatted Sudan Sudan document.

Some Issues: Road Environments

As drafting of the SS LVR Manual has progressed .it has become more evident that there a significant differences between the road environments of S Sudan and Ethiopia that is having an impact on the focus and relative emphasis of key design approaches.

Key differences exist for example with regard to:

Terrain models

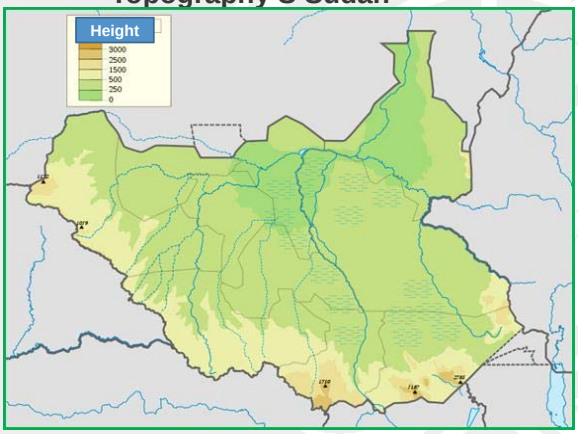
Climate

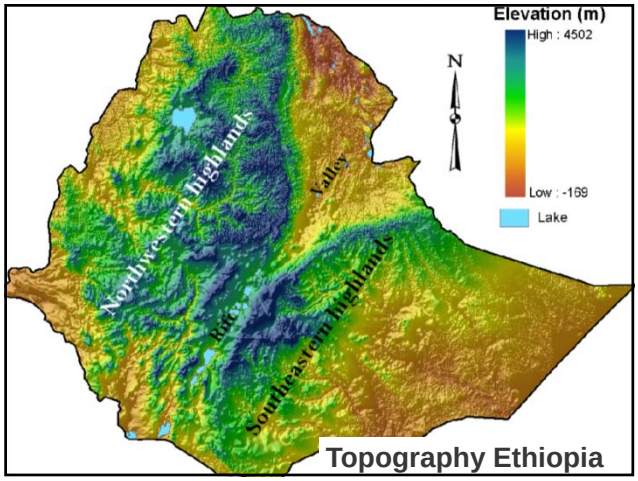
Hydrology

Traffic and its forecasting

Contracting regime

Topography S Sudan





Topography Ethiopia

Status of Draft Manual

Main Volume: (Volume I)		
1	Introduction	Drafted
2	Legal Framework and Ownership	Drafted
3	The Approach to LVR Design	Drafted
4	South Sudan Road Environments	Drafted
5	Route Selection and Investigation	1st Draft
6	Geometric Design	1st Draft
7	Natural Construction Materials	1st Draft
8	Surfacing and Pavement Design	1st Draft
9	Drainage and Structures	1st Draft
10	Road side Slope Stability	1st Draft
11	Spot Improvement	Outline
12	Maintenance	1st Draft

1st drafts require rationalisation and some tables & figures

Appendices

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Appendices A (Volume II)		
A1	Traffic Analysis	To be drafted
A2	Materials Testing	To be drafted
A3	Marginal Materials	To be drafted
A4	Drainage calculations	To be drafted
A5	Swelling Clays	Outlined
A6	Design Compliance	To be drafted
A7	Environmental Assessment	To be drafted
A8	Complementary Initiatives	To be drafted

Volume 2

UNOPS

Cross Drainage and Structures		
1	Text Chap 1-8	1st Draft
	There is some rationalisation to be done between sections in this volume and some sections in Volume 1	
2	Standard Drawings	To Be reviewed

Volume 3

UNOPS

Maintenance Booklet		
1	Text Chap 1-15	1st Draft
	There is some editing to be done on some figures and tables	

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Ministry of Roads and Bridges

Low Volume Roads (LVR)
Design Manual for South Sudan

Programme

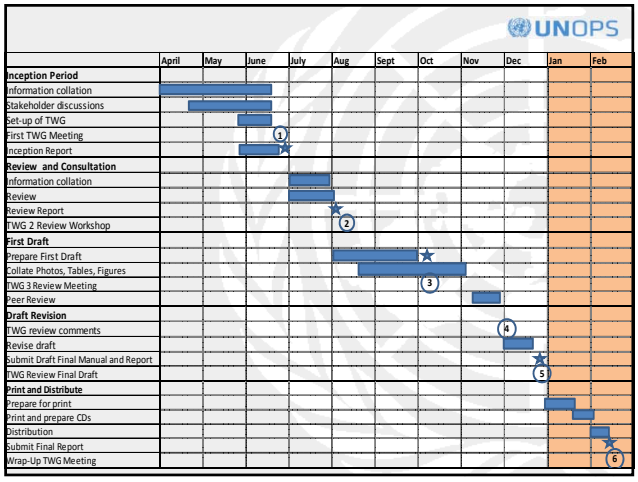
Dr Jasper Cook
Rob Petts

Programme Review

We need to look at the current programme in the light of the outstanding actions

Actions to be Completed

- Rationalisation of text between chapters/volumes
- Fill-in some gaps in main text
- Complete Appendices
- Edit figures, some tables
- Insert plates
- Peer review
- Edit-in peer review comments
- Final overall edit and preparation for printing
- Print and prepare DVDs
- Dissemination



Additional Technical Guidance

- Technical Design Specifications,
- Maintenance Specifications,
- Standard Bidding and Contract Documentation,
- Construction Good Practice
- Cost-Benefit Assessment
- Whole-life Costing and Cost model

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Ministry of Roads and Bridges

Low Volume Roads (LVR) Design Manual for South Sudan

Volume I: Main Text

Jasper Cook
Rob Petts

CHAPTER 1: INTRODUCTION: CONTEXT AND SCOPE OF THE MANUAL UNOPS

Introduces the SS LVR Manual and its aims and target user audience. It will outline the basic concepts and principles and the scope of the guidance provided by the manual (applicable for routes carrying up to 300 motor vehicle equivalent vehicles per day).

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The successful design of low volume roads relies on the Following

- A full understanding by the design engineer of the local environment (natural, operational and social);
- An ability to work within the demands of the local environment and to turn these to a design advantage;
- Recognition and management of risk;
- Innovative and flexible thinking through the application of appropriate engineering solutions rather than following traditional High Volume, high cost thinking related to road design;
- A client who is open and responsive to innovation
- Realistic assessment and arrangements for maintenance needs and capacity

Issue for Discussion UNOPS

Road Classification and Categorisation for Geometric Design of Roads.

A classification system based on road function has been adopted for classifying the SouthSudan road network in line with international good practice.

Basic Function	Class Number	Class Name	Route Number Prefix
Mobility	1	International	N
	2	Interstate	A
	3	State	B
Access	4	County	C
	5	Local	D
	6	Walkway	-

Proposed Categorization for Geometric Design of Roads

Traffic Grouping	Geometric Standards	Intended Level of Service	AADT
High Volume (HVR)	Refer to South Sudan Geometric Design Manual 2006 DS1 – DS4	A and B (Paved)	>300
Low Volume (LVR)	DC4	C (Paved or Unpaved)	150 - 300
	DC3		75 – 150
	DC2		25 – 75
	DC1	D (Unpaved)	<25
	Track		-

Chapter 2: LEGAL FRAMEWORK AND OWNERSHIP

states the ownership and South Sudanese entities contributing to the development of the manual, and authority to use the manual for different types of road.

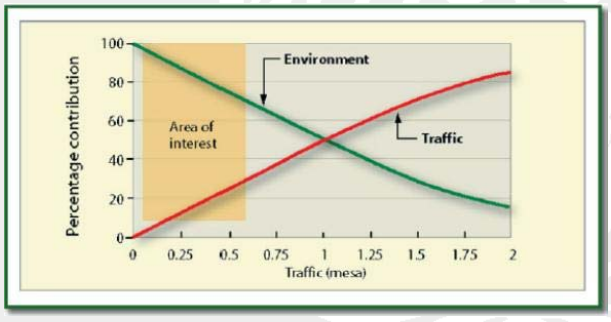
Key Points Chapter 3

This Chapter introduces the broad strategies for **LVR design** in South Sudan with an emphasis on Environmentally Optimised Design (EOD) and the appropriate use of available resources that allows:

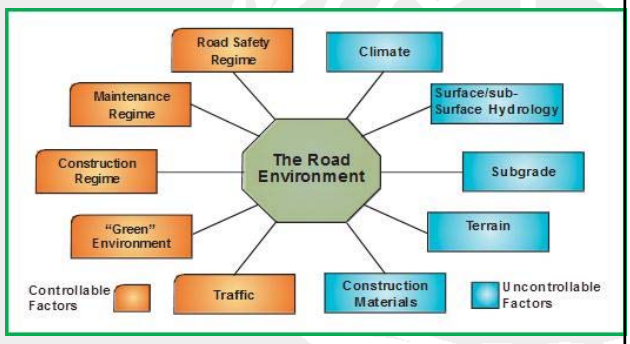
- Best use to be made of existing limited sector funds and resources
- Provision of strategic routes with year round (full) access
- Basic access to the majority of the population for most of the year
- Roads that are suitable for the types of traffic that will use them
- Roads that are serviceable and safe for the users and general public
- Roads that are cost-effective within their life cycle
- Minimisation of the impact on the environment
- The best use of available local resources,
- Encouragement of the development of local capacity

Key Points Chapter 4

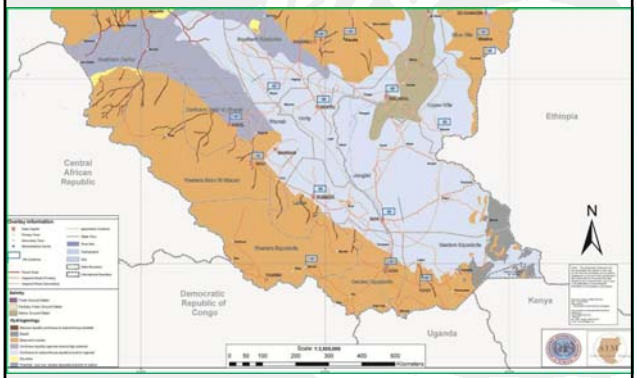
Chapter 4 summarises the key **Road Environment** factors to be taken into account in LVR design



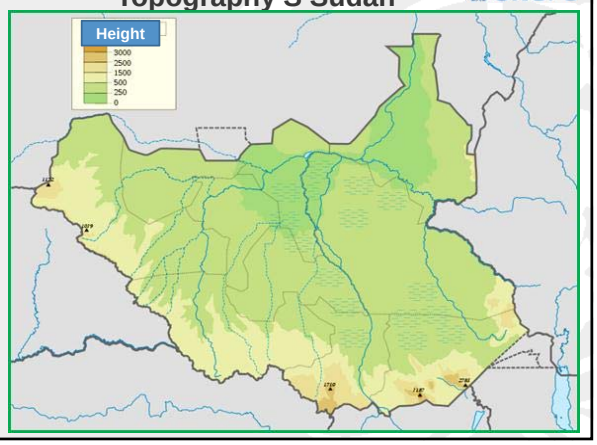
The Road Environment

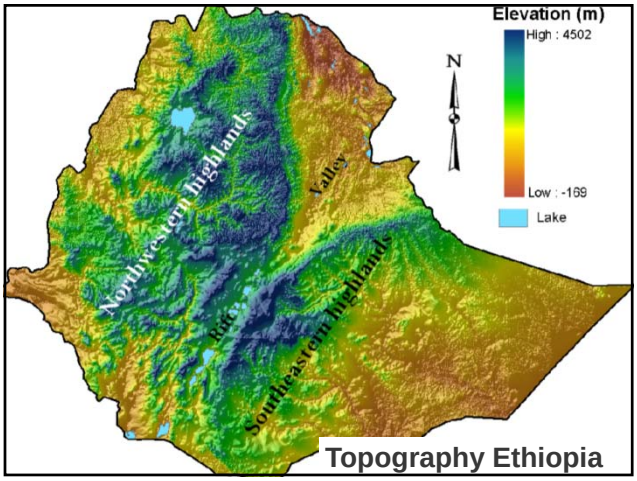


Key Points Chapter 4



Topography S Sudan





Topography Ethiopia

Chapter 5 Route Selection and Geotechnical Investigations

This chapter puts emphasis on logically phased investigations that are linked into the overall Road Life Cycle and that are aimed at:

- Selection of the route/alignment of the road;
- Location of water crossings and drainage structures;
- Design information for the road pavements, bridges and other structures;
- Areas for specialist geotechnical investigation;
- Areas of potentially problematic soils requiring additional investigation and treatment;
- Location and assessment of suitable, locally available borrow and construction material.

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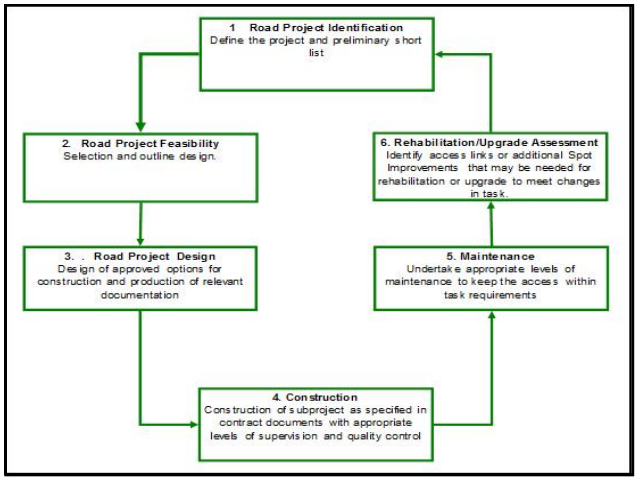
Chapter 5
Route Selection and Geotechnical Investigation

- 5.1 Introduction
- 5.2 Site Investigation Components
- 5.3 Principal Considerations for Route Selection
- 5.4 Site Investigation Procedures
- 5.5 Desk Studies
- 5.6 Walkover Surveys and Geotechnical Mapping
- 5.7 Ground Investigations
- 5.8 Laboratory Test Programmes
- 5.9 Investigations for Project Phases



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Desk study	Walkover Survey	Ground Investigation	Laboratory Testing
Air photographs, existing boreholes, historical maps, geological maps, soil maps, climatic data, land use, design specifications.	Mapping of soil conditions, construction material availability, geomorphology, grade or alignment problems, water crossing and drainage problems, site acces difficulties	Boreholes probes and test pits to further establish ground profile, insitu strength testing	Determine materials design parameters

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Chapter 5 Discussion Points/Queries

- Site Investigation resources in S Sudan
- Locations of existing geotechnical records
- Testing facilities
- Testing records

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Chapter 6 GEOMETRIC DESIGN

- 6.1 Introduction
- 6.2 The principal factors determining geometric standard
- 6.3 Cross sections
- 6.4 Design speed and geometry
- 6.5 Horizontal alignment
- 6.6 Vertical alignment
- 6.7 Harmonisation of horizontal and vertical alignment
- 6.8 Safety 2
- 6.10 Road Markings
- 6.11 Lighting
- 6.12 Safety barriers
- 6.13 Using the Geometric Standards
- 6.14 LVR Geometric Design Standards

UNOPS

SS LVR draft Design Manual

Geometric Issues

By
Robert Petts

UNOPS

Geometrics

In South Sudan the Geometric Standards for LVR need to be influenced by:

- **Traffic type and flow**
- **Topography**
- **Soil characteristics**
- **Rural / 'Urban' situation**

Main Roads Manual

UNOPS

Table 2-1: Design Standards vs. Road Classification and AADT

Road Functional Classification	Design Standard	Design Traffic Flow (AADT)*	Surface Type	Width (m)		Design Speed (km/hr)				Urban/Peri-Urban
				Carriageway	Shoulder	Flat	Rolling	Mountainous	Escarpment	
FEEDER / COLLECTORS / MAIN ACCESS / INTER-STATE	DS1	10000–**15000	Paved	***Dual 2 x 7.3	See T.2-2	120	100	85	70	50
	DS2	5000–10000	Paved	7.3	See T.2-2	120	100	85	70	50
	DS3	1000–5000	Paved	7.0	See T.2-2	100	85	70	60	50
	DS4	200–1000	Paved	6.7	See T.2-2	85	70	60	50	50
	DS5	100– 200	Unpaved	7.0	See T.2 -2	70	60	50	40	50
	DS6	50–100	Unpaved	6.0	See T.2-2	60	50	40	30	50
	DS7	30–75	Unpaved	4.0	See T.2-2	60	50	40	30	50
	DS8	25–50	Unpaved	4.0	See T.2-2	60	50	40	30	50
	DS9	0–25	Unpaved	4.0	See T.2-2	60	40	30	20	40
	DS10	0–15	Unpaved	3.3	See T.2-2	60	40	30	20	40

Geometrics - Issues

UNOPS

SS Main Roads manual :

1. uses 6 categories (DS5 - 10) for LVRs and these only go to AADT 200. The next category is DS4 covering AADT 200-1000, which clearly ranges beyond LVRs.
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Based on collective international LVR expertise, the following is proposed ……

Geometrics

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Proposed Categorization for Geometric Design of Low Volume Roads in SS

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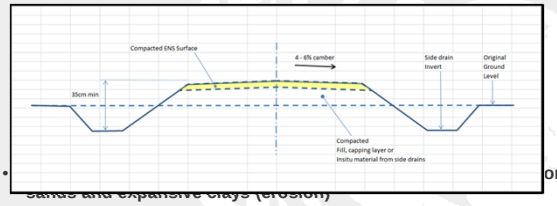
Low Volume (LVR)	DC4	C (Paved or Unpaved)	150 - 300
	DC3		75 – 150
	DC2		25 – 75
	DC1	D (Unpaved)	<25
	Track		-

Side Drains

UNOPS

ERA LVR advises minimum side drain depth of 20cm



- **or**
- **Trapezoidal or V options**

Chapter 7
CONSTRUCTION MATERIALS

- **7.1 Introduction**
- **7.2 The Use of Locally Available Materials**
- **7.3 Construction Material Requirements**
- **7.4 Material Improvement**

Key Principles

The maximum use of naturally occurring unprocessed materials is a central pillar of the LVR design philosophy. Current specifications tend to exclude the use of many naturally occurring, unprocessed materials (natural soils, gravel-soil mixtures and gravels) in pavement layers in favour of more expensive crushed rock, because they often do not comply with traditional requirements. However, recent research work has shown quite clearly that so-called “non-standard” materials can often be used successfully and cost-effectively in LVR pavements provided appropriate precautions are observed

If the project is in an area where good quality construction materials are scarce or unavailable, alternate solutions that make use of the local materials should be considered to avoid long and expensive haulage. For example consideration should be given to:

- Modifying the design requirements
- Modifying the material (eg mechanical or chemical stabilization)
- Material processing (eg crushing, screening, blending)
- Innovative use of non-standard materials (particularly important for low traffic roads

Requirements Outlined

Road construction materials required may be summarised as:

- Common embankment fill;
- Capping layer / imported subgrade;
- Sub-base and road-base aggregate;
- Road surfacing aggregate;
- Paving stone (eg for cobblestone pavements);
- Aggregates for structural concrete;
- Filter/drainage material;
- Special requirements (eg rock-fill for gabion baskets

Typical Guidance on Material use: Table 7.3: Particle Size Distribution for Natural Gravel Base

Test Sieve size	Per cent by mass of total aggregate passing test sieve				
	Envelope A Nominal maximum particle size			Envelope B	Envelope C
	37.5mm	20mm	10mm		
50mm	100			100	
37.5mm	80-100	100		80-100	
20mm	55-95	80-100	100	55-100	
10mm	40-80	55-85	60-100	40-100	
5mm	30-65	30-65	45-80	30-80	
2.36mm	20-50	20-50	35-75	20-70	20-100
1.18mm	-	-	-	-	-
425µm	8-30	12-30	12-45	8-45	8-80
300µm	-	-	-	-	-
75µm	5-20	5-20	5-20	5-20	5-30
Envelope D 1.65 < GM < 2.65					

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Discussion Issues

- Use of local materials
- Derivation of local specifications
- Performance data on local materials
- Properties of local materials sources of data?

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SS LVR draft Design Manual

Pavement Design Issues

By
Robert Petts

Chapter 8 Surfacing & Pavement Design

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- 8.1 Introduction to Paving & Surfacing Options for LVR
- 8.2 Choice of Pavement and Surfacing
- 8.3 Surfacing Design traffic classes for LVR
- 8.4 Design of Engineered Natural Surfaces (ENS)
- 8.5 Design of Natural Gravel Roads
- 8.6 Structural Design of Paved Roads
- 8.7 Pavement Drainage and Shoulders

Surface Options

- **Basic**
- S-01: Engineered Natural Surface (ENS)
- S-02: Natural gravel

- **Stone Paving**
- S-03: Waterbound/Drybound Macadam (WBM - DBM)
- S-04: Hand Packed Stone (HPS)
- S-05: Stone Setts or Pavé (SSP and MSSP)
- S-06: Mortared Stone (MS)
- S-07: Dressed stone/cobble stone (DS, CS, MDS, MCS)

- **Fired Clay Brick**
- S-08: Unmortared/mortared joints (CB, MCB)

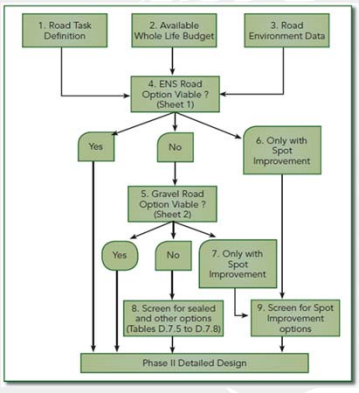
Surface Options

- **Bituminous**
- S-09: Sand Seal
- S-10: Slurry Seal
- S-11: Chip Seal
- S-12: Cape Seal
- S-13: Otta Seal

- **Concrete**
- S-14: Non-reinforced concrete (NRC)

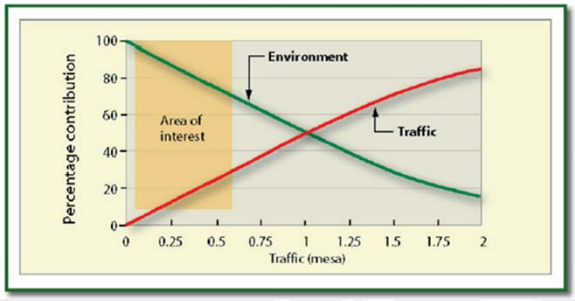
  - UTRC excluded
  - Many are local resource (labour & materials) based : use should depend on local circumstances
  - Selection process guidance provided

Surface Options Selection Process



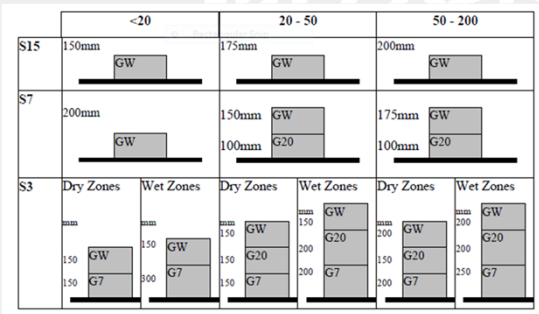
Surface Options

Importance of road environment

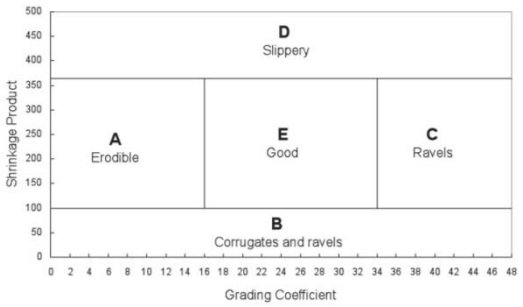


Gravel Design

Design based on Traffic flow and subgrade strength



Gravel Properties



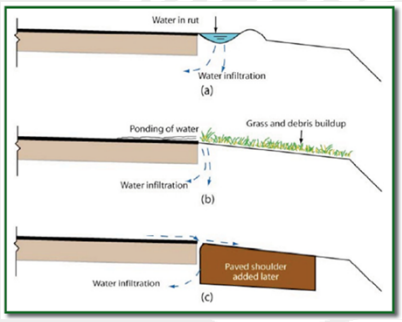
Surface Gravel Loss

Expected Annual Gravel Loss (mm) depending on gravel properties

Material Quality Zone[1]	Description of Material Quality	Typical gravel loss (mm/yr/100vpd)
Zone A	Satisfactory	20
Zone B	Poor	45
Zone C	Poor	45
Zone D	Marginal	30
Zone E	Good	10

Pavement Drainage

Guidance provided on Shoulder details for 'sealed' roads



Discussion

Any comments or contributions welcome

Geometrics

In South Sudan the Geometric Standards for LVR need to be influenced by:

- **Traffic type and flow**
- **Topography**
- **Soil characteristics**
- **Rural / 'Urban' situation**

Main Roads Manual

Table 2-1: Design Standards vs. Road Classification and AADT

Road Functional Classification	Design Standard	Design Traffic Flow (AADT)*	Surface Type	Width (m)		Design Speed (km/hr)				Urban/Peri-Urban
				Carriageway	Shoulder	Flat	Rolling	Mountainous	Escarpment	
INTER-STATE	DS1	10000-**15000	Paved	***Dual 2 x 7.3	See T.2-2	120	100	85	70	50
	DS2	5000–10000	Paved	7.3	See T.2-2	120	100	85	70	50
	DS3	1000–5000	Paved	7.0	See T.2-2	100	85	70	60	50
	DS4	200–1000	Paved	6.7	See T.2-2	85	70	60	50	50
ACCESS	DS5	100– 200	Unpaved	7.0	See T.2 -2	70	60	50	40	50
	DS6	50–100	Unpaved	6.0	See T.2-2	60	50	40	30	50
	DS7	30–75	Unpaved	4.0	See T.2-2	60	50	40	30	50
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MAIN COLLECTORS / FEEDER

Geometrics - Issues

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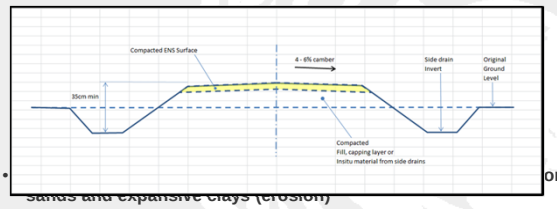
	Track		-

Side Drains

UNOPS

ERA LVR advises minimum side drain depth of 20cm



- **or**
  - **Sands and expansive clays (erosion)**
- **Trapezoidal or V options**

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Chapter 9: Road Drainage

The Chapter is essentially a guide containing appropriate technical explanations of all the steps in designing the surface water drainage system for LVRs.

Principal Author: Fergus Gleeson

UNOPS

Chapter 9
Road Drainage

- 9.1 Introduction
- 9.2 Summary of Standards and Departures
- 9.3 Hydrology: Estimating Maximum Flow
- 9.4 Components of External Drainage
- 9.5 Erosion Control

Standards:Design Storm Return Period (years)

Structure type	Geometric design standard	
	C4	C5
Gutters and inlets	2	2
Side ditches	5	5
Ford	5	5
Drift	5	5
Culvert diameter <2m	10	10
Large culvert diameter >2m	15	10
Gabion abutment bridge	20	15
Short span bridge (<10m)	25	15
Masonry arch bridge	25	25
Medium span bridge (15 – 50m)	50	25
Long span bridge >50m	100	50

High Risk Return Period – No alternative within 75 Km??

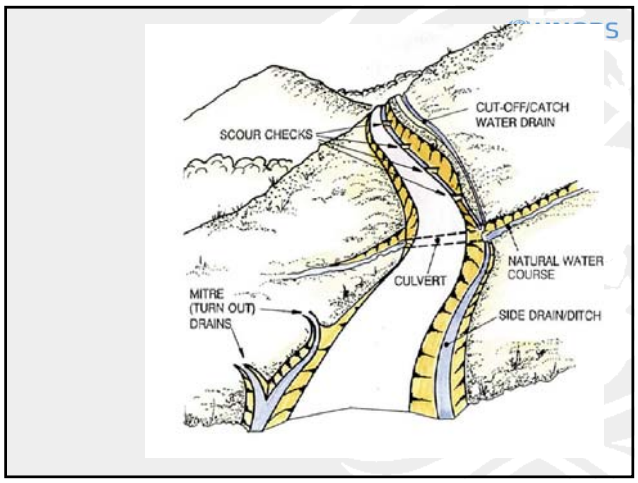
Structure type	**Geometric design standard**	
	C4	**C5**
Gutters and inlets	5	5
Side ditches	10	10
Ford	10	10
Drift	10	10
Culvert diameter <2m	20	20
Large culvert diameter >2m	25	20
Gabion abutment bridge	25	20
Short span bridge (<10m)	50	25
Masonry arch bridge	50	25
Medium span bridge (10 – 50 m)	100	50
Long span bridge >50m	100	100

Components of External Drainage

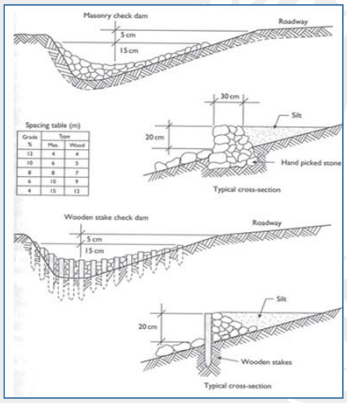
- An effective external drainage system must fulfill several functions:
- Prevent or minimise the entry of surface water into the pavement;
- Prevent or minimise the adverse effects of sub-surface water;
- Remove water from the vicinity of the pavement as quickly as possible;
- Allow water to flow from one side of the road to the other.

External Drainage Components

- Surface drainage (i.e. camber).
- Side drainage to:
  - Take water from the road;
  - Prevent water from reaching the road.
- Turnouts
- Cross drainage.
- Interceptor drains
- Sub-surface drains.
- Erosion control



Typical Designs: Scour Checks



Chapter 10
Road-Side Slope Design & Stabilisation

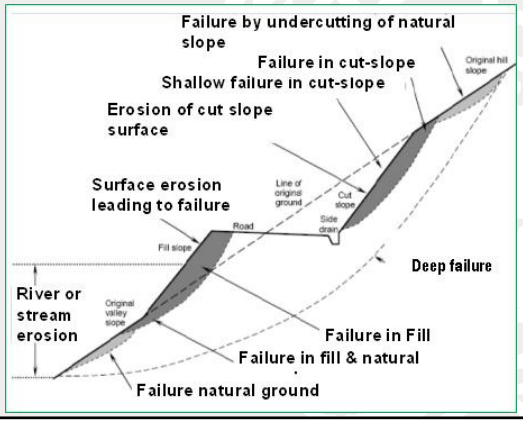
- 10.1 Introduction
- 10.2 Cut-slopes
- 10.3 Embankments
- 10.4 Cut-fill Cross Sections
- 10.5 Roadside Slope Instability
- 10.6 Instability Types
- 10.7 Slope Protection and Stabilisation
- 10.8 Bio-engineering

Introduction

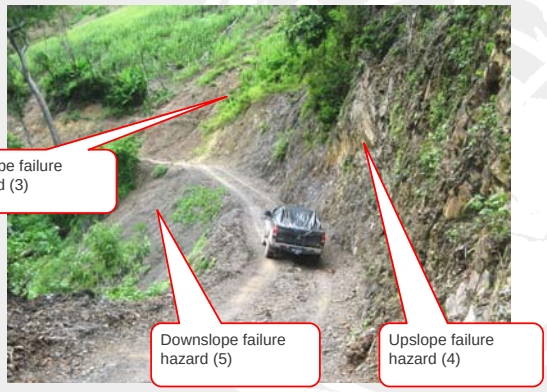
In order to comply with horizontal or vertical geometric guidelines and thus permit reasonable access for users, LVR alignments in hilly or mountainous areas may require the construction of cuts or embankment earthworks. On low plain areas liable to flood it may be necessary to raise roads on embankment.

The aim of any low cost approach to earthworks design is to excavate to safe slope angles without having to resort to extensive use of support structures. However, the interaction of LVR route alignment and the geometry or instability of the natural slopes may be such that construction to recognised safe angles is not an economical or engineering feasibility Engineered stabilisation may have to be considered, particularly in areas of identified natural hazard.

Failure Types



Typical Road Hazards

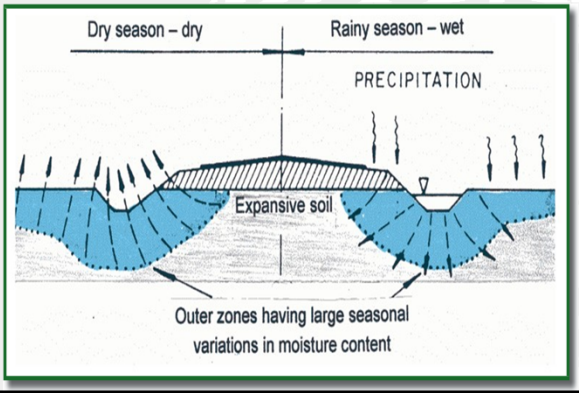


59

Embankments on Soft Ground

- **Replacement**: The weak or problem soil is removed, either partly or completely, and replaced by suitable material: The economic limits to full removal would be around 3-4 m.
- **Counterweight Berms**: The principle of counterweight berms is to add weight to the toe of the embankment to increase the resistance against slip or lateral spreading.
- **Surcharging:** Surcharging involves placing temporary additional load onto the proposed embankment to increase primary settlement.
- **Staged Construction**: Allows consolidation to progress and undrained strength increase in the soft soil under the embankment load before adding successive fill lifts..

Earthworks on Expansive Clay



Expansive Soil General Embankment Options

1. Removal of the expansive soil and replacement with non-expansive material
2. Design for the low strength and allow for maintenance to repair heave
3. Provide non-expansive material as a cover or surcharge layer
4. Control moisture movement
5. Improve the engineering character of the expansive soil by stabilisation
6. Improve the mass engineering character of the expansive soil with geotextiles

Low Cost Engineering Works

	Seepage erosion	Face erosion	Cut soil -weathered rock failure	Cut hard rock failure	Soil fall from steep slope	Rockfall from steep slope	Down slope failure	Downslope erosion	Deep failure of rock cut slope
Gabion netting						■			
Retaining walls			■				■	■	
Revetment walls	■	■						■	
Masonry protection	■	■						■	
Dental concrete				■		■			
Concrete buttress			■	■					
Soil-rock bolts				■		■			
Soil-rock buttress							■		■

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Bio-engineering?

Bio-engineering is the use of living vegetation, either alone or in conjunction with civil engineering structures and non-living plant material, **to reduce shallow-seated instability and erosion**.

It is mainly about the use of plants to provide surface protection on slopes.

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Why Use Bio-engineering?

1. Reduce erosion and shallow instability (< 0.5 metre).
2. Increase a slope's factor of safety.
3. Physical flexibility: plants adapt and re-grow if there is settlement in a slope.
4. Versatility in application
5. No other measures can protect surfaces over such a large scale.
6. Cost-effectiveness:
7. Environmentally advantageous.
8. Socially advantageous

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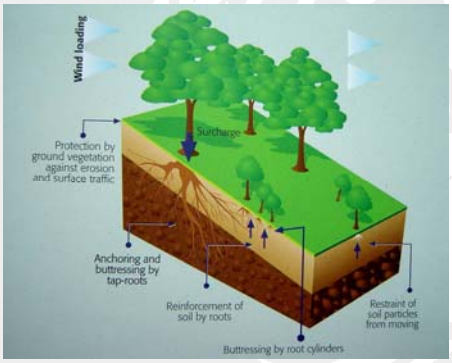
Functions of Plants on Slopes: Physical



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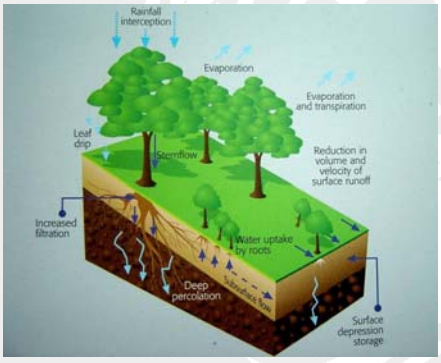
Functions of Plants on Slopes: Hydrological



Chapter 11 Spot Improvement

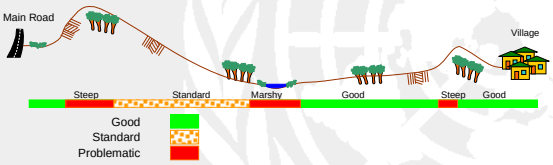
- 11.1 Introduction
- 11.2 Principles
- 11.3 Appropriate Use
- 11.4 Procedures

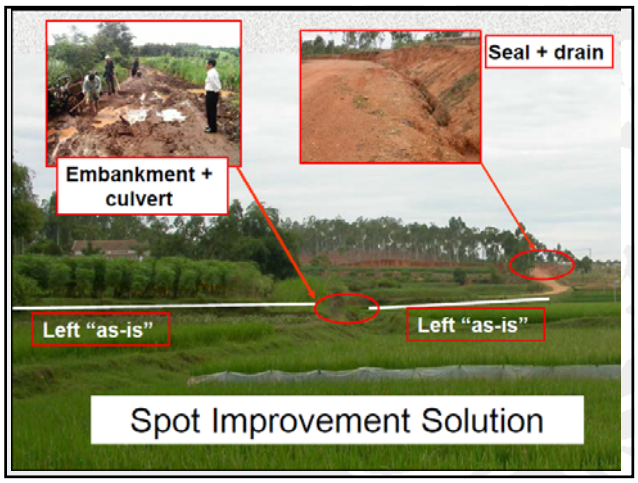
Key Points Chapter 11

Spot Improvement involves the appropriate improvement of specifically identified road sections or structures either in actual need of upgrade or deemed to be at high risk of failure, and allows the appropriate application of limited resources to be targeted at key areas..

Guidance will be provided on selection and design of Spot Improvements which must be seen as fully engineered options to meet defined requirement over the design life of the road and not as interim maintenance options.

Spot Improvement





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Spot Improvements: Prioritisation of actions

Priority criteria			
1	Unsafe - high risk	8	Unstable slope
2	Impassable at any time	9	Environmental concerns
3	Impassable in wet only	10	Very slow travel
4	Condition likely to deteriorate	11	Geom cross sect below standard
5	Health risk	12	Geometry below standard
6	Drainage in poor condition	13	Surface below standard
7	Unsafe - medium risk	14	Pavement below standard

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Chainage From	Chainage To	Description	Gradient (%)	Current condition	Subgrade CBR (%)	Required work	Priority criteria	Cost ($)
0	0.6	Gentle	1	Fair	5	Gravel	14	9,500
0.6	0.8	Village	2	Fair/dusty	12	Surface & base	5	8,000
0.8	1.2	Gentle	2	Very rough	6	Gravel	10	5,500
1.2	1.5	Steep hill	10	Very poor	8	Surface & base	2	13,500
1.5	2.8	Flat	0	Fair	6	Gravel	14	19,500
2.8	3.2	Occasional flooding	0	Soft/poor	2	Embank & surface	3	22,000
3.1		Missing culvert		Impassable in rain		New culvert	3	5,000
3.2	3.9	Gentle	1	Fair	4	Gravel	14	10,500
3.9	4.5	Steep hill	5	Very poor	8	Surface & base	2	26,000
4.5	4.8	Flat ridge	0	Good	15	Gravel	14	4,500
4.8	5.4	Landslips	3	Fair	3	Gravel & protect	8	12,000
5.4	6.1	Gentle	1	Fair	5	Gravel	14	10,500
6.1	6.5	Village	2	Good	10	Surface & base	5	17,000
							Total	163,500

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SS LVR draft Design Manual

Small Structures

By
Fergus Gleeson

Approach

- Separate Volume of the Manual on Small Structures for LVRs
- Compiled by adaptation from Parts C, D and E of the ERA LVR Manual and other references
- Basically covers Small Structures up to 10m span, drifts, culverts and retaining walls
- Materials options include masonry, brick and timber as well as un-reinforced and reinforced concrete

Issues for Discussion

- For larger and complex structures, readers will be directed to the SS 2006 series manuals and other knowledge sources
- Should structures design category be based on road functional classification category or traffic flow category?
- Should the '75km alternative route criteria' be changed?

Issues for Discussion

This table based on 'Functional' category
C4 = county
C5 = local

Table 3.1: Design storm return period (years)

Structure type	Geometric design standard (2)	
	C4	C5
Gutters and inlets (1)	2	2
Side ditches (1)	5	5
Ford (1)	5	5
Drift (1)	5	5
Culvert diameter <2m (1)	10	10
Large culvert diameter 2 - 6m	15	10
Gabion abutment bridge	20	15
Short span bridge 6 - 10m	25	15

1. These periods should be doubled if the alternative route in the event of a drainage failure is more than an additional 75km, or no alternative exists.

Issues for Discussion

Basic Function	Class Number	Class Name	Route Number Prefix
Mobility	1	International	N
	2	Interstate	A
	3	State	B
Access	4	County	C
	5	Local	D
	6	Walkway	-

Traffic Grouping	Geometric Standards	Intended Level of Service	AADT
High Volume (HVR)	Refer to South Sudan Geometric Design Manual 2006 DS1 – DS4	A and B (Paved)	>300
Low Volume (LVR)	DC4	C (Paved or Unpaved)	150 - 300
	DC3		75 – 150
	DC2		25 – 75
	DC1	D (Unpaved)	<25
	Track		-

Discussion

Are Criteria for Drift being appropriate realistic?

Table 4.7: Closure Times (See Comment)

Criteria	Drift most favourable	Drift least favourable
Average daily traffic (ADT)	Less than 5 vehicles per day	More than 200 vehicles per day
Average annual flooding	Less than twice per year	More than 10 times per year
Average duration of traffic interruption per occurrence	Less than 24 hours	More than 3 days
Extra travel time for detour	Less than 1 hour	More than 2 hours/no detour

N.B – See comment, this is a key decision for the TWG and Manual owners.

Discussion

Flood discharge estimation

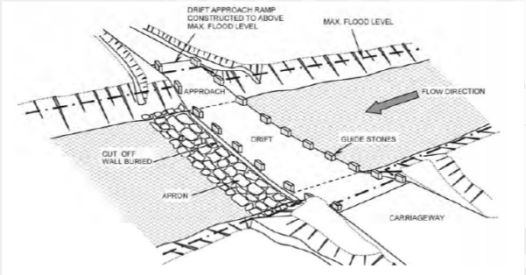
- ERA method too complex and 'data hungry'
- SS Main roads manual method recommended with cautionary note due to generally large catchments
- General lack of rainfall data?
- What data is available to be referenced?

Discussion

- 'Construction' chapter removed as this was thought to be more appropriately contained in a separate 'Construction' Manual on all aspects of LVR works
- Do the TWG Members see any benefit in reducing the current Main Volume 2, Part 1 in length through removing some of the field-testing data and properties of materials to the materials appendix?
- ***Please*** can TWG members contribute suitable local photographs to help support the text to make the document feel more South Sudanese!

Discussion

Any comments or contributions welcome



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SS LVR draft Design Manual

Maintenance

By
Robert Petts

UNOPS

Chapter 12

- 12.1 What is Maintenance?
- 12.2 What is the Essence of Road Maintenance?
- 12.3 What Maintenance needs to be done?
- 12.4 Regular Maintenance
- 12.5 Occasional Maintenance
- 12.6 Maintenance Implementation Options
- 12.7 In Summary

Approach

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- Chapter in the main Manual
- Separate self contained Maintenance Booklet

Booklet Contents

UNOPS

- What is Maintenance?
- What needs to be done to achieve all-year Basic Road Access,
- How to identify the main problems/defects and solve them,
- How to make the most of local materials and skills,
- How to maintain the road access at low cost,
- How to make priorities
- How to organise and plan the work
- Where to obtain further advice and outside assistance.

Key Concepts

- view **Maintenance** as correcting **Defects**
- Include new scope of **structures** maintenance
- Allow technology options
- Encourage maintenance capacity assessment at design stage
- Grouping of defects and maintenance activities
- Set out various implementation options
- Guidance on management, priorities & seasonality
- Guidance on planning and productivity

Approach

Grouping & Colour coding of Defect and Maintenance Activities

Regular Maintenance (Routine)

- Roadside Activities
- Drainage
- Road Surface
  - Earth Road
  - Gravel Road
- Structures

Occasional Maintenance (Periodic)

- Road Surface
  - Gravel Road
  - Paved Road
- Structures

Implementation Options

- **Option 1- Small Contractor (Private)**
- **Option 2 - Force Account**
- **Option 3- Community Group**
- **Option 4 - Length Person or Family Contract**
- **Option 5 - Compulsory/Voluntary Labour**
- **Option 6 - Hire-in equipment**
- **Option 7- Large Contractor Based System**

Discussion

Any comments or contributions welcome