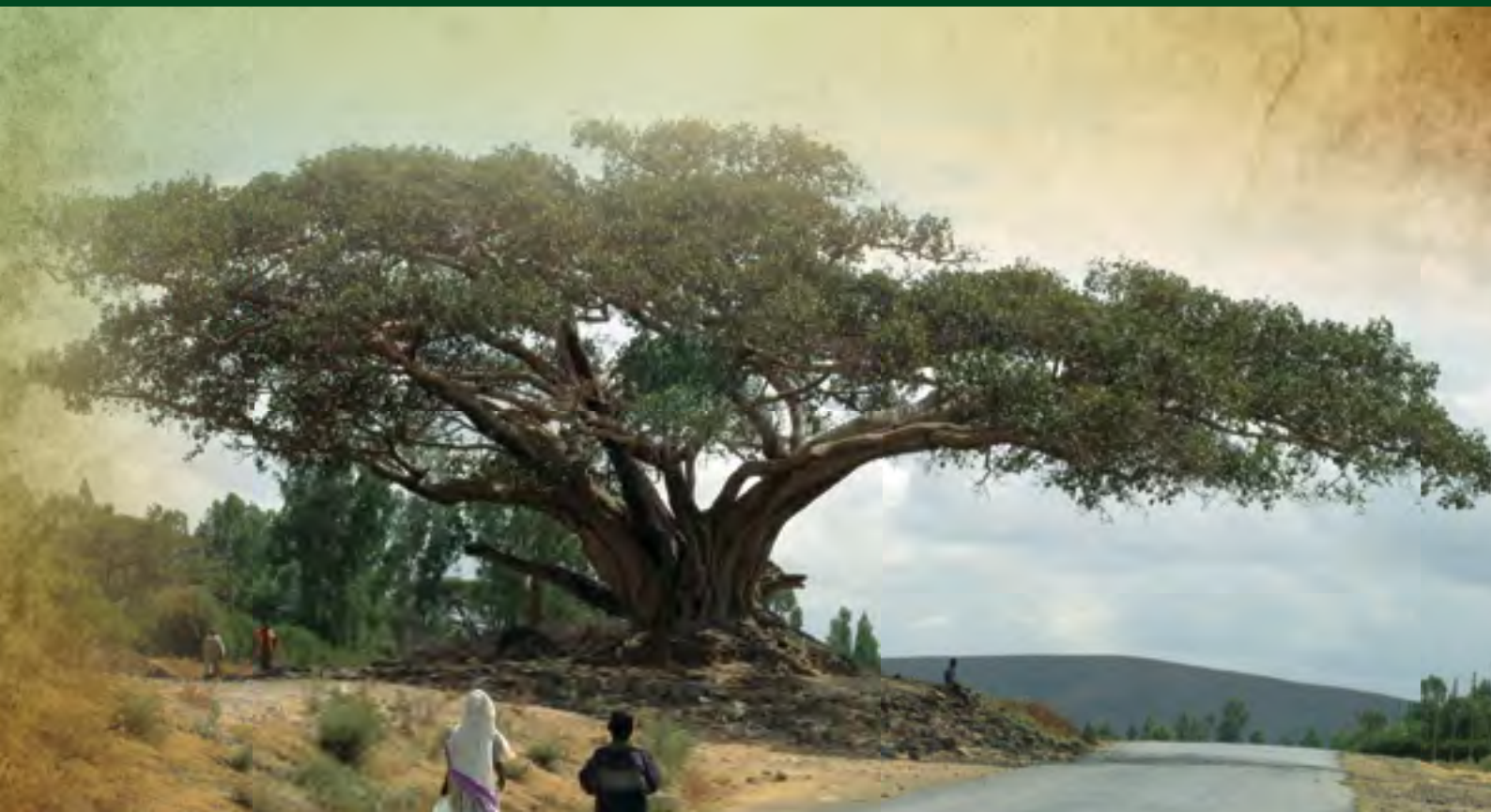
FEDERAL DEMOCRATIC REPUBLIC OF

ETHIOPIA

ETHIOPIAN ROADS AUTHORITY

DESIGN MANUAL FOR LOW VOLUME ROADS
PART A, PART B AND PART C

FINAL DRAFT, APRIL 2011



FOREWORD

Low volume roads in Ethiopia typically carry less than 300 vehicles per day and provide important links from homes, villages and farms to markets and offer the public access to health, education and other essential services. These roads also provide important links between Wereda Centres and the Federal road network.

Many aspects of the design and construction of roads in Ethiopia, has stemmed from technologies and practices emanating from Europe and the USA some 40 years ago. These practices have to some extent been modified in the intervening years, but the basic philosophy of road provision has remained the same. While these "standard" approaches might still be appropriate for much of the main trunk and link road network, they remain overly conservative, inappropriate and far too costly for application on much of the country's rural road network. In facing the challenges of improving and expanding Ethiopia's low volume rural road network, application of the traditional planning, design, construction and maintenance approaches cannot provide the solution.

Many innovative practices and unconventional techniques, often developed and proved through years of research, have not found the degree of application and implementation that they should. Opportunities are missed that would provide better and lower cost engineering solutions and more sustainable low volume roads.

There is a wealth of local and international information, experience and research that when utilised, can change current practices and thinking and provide Ethiopia with an appropriate and affordable low volume road network. To benefit fully from these advances and to see necessary improvements implemented on the ground, Ethiopian Roads Authority (ERA) has developed its first comprehensive national road design manual, technical specifications and bidding documents specifically for low volume roads. The task was completed with the assistance of a team of international experts commissioned through DFID's Africa Community Access Programme (AFCAP).

Compilation of the documents was undertaken in close consultation with the local industry and regional authorities. The Federal and Regional Roads Authorities, the contracting and consulting industry, the universities, training schools, the road fund and other industry stakeholders all participated in the formulation of the documentation. Local issues and experience on the geometric, earthwork, drainage, pavement and surfacing design for low volume roads were discussed and debated at length. Of particular interest were aspects of better use of local materials; materials selection and specification; testing and improvement of materials; construction methods and the utilisation of approaches such as labour-based and intermediate equipment technology; route selection; works specifications; and contracting of small works. Much of this debate and other resource materials developed during the compilation of the manual have been captured and are available from the ERA website: www.era.gov.et

Importantly, in supporting the preparation of the documents, a series of thematic peer review panels were established that comprised local experts from the public and private sector who provided guidance and review for the project team. Mainstreaming of social and cross-cutting aspects received special attention and a peer panel of local experts developed a welcome addition to the design process in terms of complementary interventions.

On behalf of the Ethiopian Roads Authority I would like to take this opportunity to thank DFID, Crown Agents and the AFCAP team for their cooperation, contribution and support in the development of the low volume roads manual and supporting documents for Ethiopia. I would also like to extend my gratitude and appreciation to all of the industry stakeholders and participants who contributed their time, knowledge and effort during the development of the documents. Special thanks are extended to the members of the various Peer Panels whose active support and involvement guided the lead authors and the process.

I trust that the low volume roads manual will provide the essential information needed to guide our design engineers in the provision of appropriate and sustainable low volume roads.

Zaid Wolde Gebriel

Director General of the Ethiopian Roads Authority

PREFACE

The Ethiopian Roads Authority is the custodian of the series of technical manuals, standard specifications and bidding documents that are written for the practicing engineer in Ethiopia. The series describe current and recommended practice and set out the national standards for roads and bridges. They are based on national experience and international practice and are approved by the Director General of the Ethiopian Roads Authority.

This Design Manual for Low Volume Roads (2011) forms part of the Ethiopian Roads Authority series of Road and Bridge Design documents.

Companion documents and manuals include the Standard Technical Specifications, Standard Detailed Drawings and Standard Bidding Documents.

The complete series of documents, covering all roads and bridges in Ethiopia, are contained within the series:

- Geometric Design Manual – 2011
- Site Investigation Manual – 2011
- Geotechnical Design Manual for Slopes - 2011
- Pavement Design Manual Volume I – 2011 (Flexible and Unpaved Pavements)
- Pavement Design Manual Volume II – 2011 (Rigid Pavements)
- Drainage Design Manual – 2011
- Bridge Design Manual – 2011
- Low Volume Roads Design Manual – 2010
- Standard Environmental Procedures Manual – 2002
- Standard Technical Specifications – 2011
- Standard Detailed Drawings – 2011
- Standard Bidding Documents for Road Work Contracts – A series of Bidding Documents covering a full range from large scale projects unlimited in value to works with an upper threshold of $300,000. The higher level documents have both Local Competitive Bidding and International Competitive Bidding versions – 2011

These documents are available to registered users through the ERA website: www.era.gov.et

1.1 Manual Updates

Significant changes to criteria, procedures or any other relevant issues related to new policies or revised laws of the land or that is mandated by the relevant Federal Government Ministry or Agency should be incorporated into the manual from their date of effectiveness.

Other minor changes that will not significantly affect the whole nature of the manual may be accumulated and made periodically. When changes are made and approved, new page(s) incorporating the revision, together with the revision date, will be issued and inserted into the relevant chapter.

This version of the Low Volume Roads Manual is released in draft for a limited period during which the industry at large is encouraged to put it into practice and to feed back to the ERA Director General any suggestions for inclusion or improvement.

All suggestions to improve the draft Low Volume Roads Design Manual should be made in accordance with the following procedures:

- Users of the manual must register on the ERA website: www.era.gov.et
- Proposed changes should be outlined on the Manual Change Form and forwarded with a covering letter of its need and purpose to the Director General of the Ethiopian Roads Authority.

- After completion of the draft review period, proposed modifications will be assessed by the requisite authorities in ERA, in close consultation with the Peer Panels and the AFCAP project team.
- Agreed changes will be approved by the Director General of the Ethiopian Roads Authority on recommendation from the Deputy Director General (Engineering Operations).
- All changes to the manual will be made prior to release of the final version of the manual.
- The release date of the final version will be notified to all registered users and authorities.

ETHIOPIAN ROADS AUTHORITY
CHANGE CONTROL DESIGN MANUAL

MANUAL CHANGE	This area to be completed by the ERA Director of Quality Assurance
Manual Title _____	CHANGE NO. _____
_____	(SECTION NO. CHANGE NO
	_____

Section Table Figure Page	Explanation	Suggested Modification

Submitted by: _____ Name/Designation: _____

Company/Organisation Address _____

_____ email: _____ Date: _____

Manual Change Action

Authority	Date	Signature	Recommended Action	Approval
Registration				
Director Quality Assurance				
Directors Region				
Deputy Director General Eng.Ops				

Approval / Provisional Approval / Rejection of Change:

Director General ERA _____ Date: _____

ACKNOWLEDGEMENTS

The Ethiopian Roads Authority (ERA) wishes to thank the UK Government's Department for International Development (DFID) through their Africa Community Access Programme (AFCAP) for their support in developing this Low Volume Roads design manual. The manual will be used by all authorities and organisations responsible for the provision of low volume roads in Ethiopia.

From the outset, the approach to the development of the manual was to include all sectors and stakeholders in Ethiopia. The input from the international team of experts was supplemented by our own extensive local experience and expertise. Local knowledge and experience was shared through a series of four *"information gathering"* workshops followed by a review workshop to discuss and debate the contents of the draft manual. ERA wishes to thank all the individuals who gave their time to attend the five workshops and provide valuable inputs to the compilation of the manual.

In addition to the workshops, Peer Groups comprising specialists drawn from within the local industry, were established to provide advice and comments in their respective areas of expertise. The contribution of the Peer Group participants is gratefully acknowledged.

The final review and acceptance of the document was undertaken by an Executive Review Group. Special thanks are given to this group for their assistance in reviewing the final draft of the document.

Finally, ERA would like to thank Crown Agents for their overall management of the project

Executive Review Group	
Individual	**Organisation**
Bizuneh Kebebe	Civil Works Consulting Engineers
Efrem Degefu	Beacon Consulting Engineers plc
Bekele Jebessa	Ethioinfra Consultants
Dawit Dejene	Civil Works Consulting Engineers
Shimeles Tesfaye	SPICE
Teshome Worku	CORE Consulting Engineers
Assefa Addisu	Assefa Social Consult
Frew Bekele	Ethiopian Roads Authority
Biniam Girma	Ethiopian Roads Authority
Alemayehu Ayele	Ethiopian Roads Authority

List of Persons Contributing to Peer Group Reviews										
			Peer Group							
No	Name	Organisation	Geometric Design and Standard Drawings	Materials & Pavement Design and Site Investigation	Technical Specifications	Standard Bidding Document	Drainage	Route Selection	Bridges	Complementary Interventions
1	Abdissa Megerssa	ERA						✓		
2	Abdo Mohammed	ERA				✓				
3	Abdurkerim Mohamed	Amhara Road Authority					✓	✓		
4	Abeba Berhanu	ERA		✓						
5	Abebe Asefa, Ato	ERA: Design & Technical Support Branch		✓					✓	
6	Addisu Mosissa	Oromia Roads Authority				✓				
7	Alemayehu Mamo	CWCE							✓	
8	Amanuel Haddush	ERA	✓							
9	Amarech Fikera	ERA					✓			
10	Andualem H/ Georgis	Beza Consulting Engineers	✓							
11	Asnake Adamu	Omega Consulting Engineers							✓	
12	Asnake Haile	Omega Consulting Engineers		✓						
13	Asrat Sewit	Saba Engineering		✓						
14	Assefa Addisu	Assefa Social Consult								✓
15	Bekele Jebessa	Ethioinfra Consultants			✓	✓				
16	Beneyam Wubshet	Dire Dawa Roads Authority	✓				✓			
17	Berhanu Tadese	AEC	✓							
18	Biniam Girma	ERA			✓	✓				
19	Bizuneh Kebebe	CWCE	✓		✓					
20	Brook Shamsu	Laber Base Association			✓	✓				✓

List of Persons Contributing to Peer Group Reviews										
			Peer Group							
No	Name	Organisation	Geometric Design and Standard Drawings	Materials & Pavement Design and Site Investigation	Technical Specifications	Standard Bidding Document	Drainage	Route Selection	Bridges	Complementary Interventions
21	Daniel Nebro	ERA	✓	✓	✓	✓				
22	Dawit Degenie	CWCE					✓		✓	
23	Dessalegn Bezabih	Ministry of Agriculture			✓			✓		
24	Efrem Degefu	Beacon Consulting Engineers		✓						
25	Efrem Gebre Egziabher	Core Consulting Engineers		✓						
26	Engda Zemedagegnehu	Private					✓			
27	Ermias Abate	CWCE		✓						
28	Ermias Ketema	Transnational Engineers						✓	✓	
29	Ezra Mersha	AEC	✓							
30	Fethi Tewfik	Harar Road Authority				✓				
31	Fikert Arega	ERA		✓				✓		
32	Frew Bekele	ERA			✓	✓				
33	Gashawe Girma	ERA		✓						
34	Genet Woldie	Bridge Engineer							✓	
35	Girma Worku	ERA							✓	
36	Haddis Tesfaye	ERA		✓	✓					
37	Hailay Techlu	Tigray Road Authority		✓						
38	Iffa Hussein	Oromia Roads Authority					✓			
39	Jamariyo Jarso	Oromia Roads Authority								✓
40	Jemal Ali	WT Consult	✓					✓		✓
41	Marshet Biru	Dire Dawa Roads Authority		✓					✓	

List of Persons Contributing to Peer Group Reviews										
			Peer Group							
No	Name	Organisation	Geometric Design and Standard Drawings	Materials & Pavement Design and Site Investigation	Technical Specifications	Standard Bidding Document	Drainage	Route Selection	Bridges	Complementary Interventions
42	Mekari Zemedagegnehu	Metaferia Consulting Engineers	✓							
43	Melaku Tadesse	Construction Contractors Association of Ethiopia			✓	✓		✓		
44	Mewael G/Kidan	Tigray Road Authority					✓			
45	Mohamed Muktar	Somali Rural Roads Authority					✓	✓		
46	Mulu Haile Michael	Dire Dawa Roads Authority						✓		
47	Muse Belew	ERA		✓	✓					
48	Saba Million	Core Consulting Engineers				✓				
49	Shimeles Tesfaye	SPICE			✓					
50	Sintayehu Melaku	Dire Dawa Roads Authority							✓	
51	Sisay Belachew	SNNP Roads Authority						✓		
52	Solomon Kulich	Scott Wilson ARE			✓					
53	Taddele Debela	Private						✓		
54	Tadesse, Ato	Private								✓
55	Tamrat Fikru	Adigerate DRMC								✓
56	Teferra Mengesha	WT Consult								✓
57	Teshome Worku	Core Consulting Engineers						✓	✓	
58	Tewodros Alene	ERA					✓	✓		
59	Tibebu Gebre	Ethioinfra Consultants	✓							
60	Yoseph Kidane	ERA			✓	✓				

Organisations represented in the LVR Project Workshops			
1	Adigerate DRMC	28	Helvetase
2	AEC	29	Laber Base Association
3	Afar Rural Roads Authority	30	Lea Consult
4	AFCAP/Crown Agents	31	Mekele University
5	Amhara Region TVET Centre	32	METAFERIA
6	Amhara Rural Roads Authority	33	Ministry of Agriculture
7	ARRB, Australia	34	Mycube, South Africa
8	Beacon Consulting Engineers plc	35	Nazerete Tractor Assembly Factory Plant
9	Benishanguel-Gumuz Rural Roads Authority	36	Omega Consulting Engineers
10	Beza Consult	37	Oromia Roads Authority
11	Construction Contractors Association of Ethiopia	38	Roughton
12	Core Consulting Engineers plc.	39	Saba Engineering
13	C-Tech Engineering	40	Scott Wilson ARE
14	CWCE	41	Shashemene
15	DFID, UK	42	SNNP Road Authority
16	Dire Dawa Roads Authority	43	Somali Region Rural Roads Authority
17	East Hararge	44	Sunshine Construction
18	Ethiopia Road Fund	45	Tigray Road Authority
19	Ethiopian Roads Authority	46	Transnational Engineers
20	Ethioinfra Consultants	47	TRL
21	Ethiopian Institue of Agricultural Research	48	TRRA
22	Finn Road	49	Unicone
23	Gambella Rural Roads Authority	50	West Hararge
24	Gimbichu Wereda Administration	51	World Bank
25	Gonder District Engineer Division	52	WSP
26	Hamda Engineering Consult plc	53	WT Consult
27	Harar Road Authority	54	Yencomad

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Abdo Mohammed	ERA	Project Coordinator
Daniel Nebro	ERA	Project Coordinator
Abeba Berhanu	ERA	Project Coordinator
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Colin Gourley	ERA and DFID	Specialist Adviser
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Les Sampson	AFCAP/Crown Agents	Project Director
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Mike Pinard	AFCAP/Crown Agents	Lead Author
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Rob Petts	AFCAP/Crown Agents	Specialist Contributor
Jasper Cook	AFCAP/Crown Agents	Specialist Contributor
Gareth Hearns	AFCAP/Crown Agents	Specialist Contributor
Gerrie van Zyl	AFCAP/Crown Agents	Specialist Contributor
Pat Loots	AFCAP/Crown Agents	Specialist Contributor

ACRONYMS

>	:	Greater than
<	:	Less than
%	:	Percentage

A

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
AFCAP	:	Africa Community Access Programme
AIDS	:	Acquired Immune Deficiency Syndrome or Acquired Immunodeficiency Syndrome
ALD	:	Average Least Dimension
ARRB	:	ARRB Group, formerly the Australian Road Research Board
ARVs	:	Antiretroviral
ASTM	:	American Standard Test Methods

B

BDS	:	Bid Data Sheet

C

CB	:	Clay Brick (fired)
CBO	:	Community Based Organisation
CBR	:	California Bearing Ratio
CI	:	Complementary Interventions
CMG	:	Crown Agents Core Management Group
COLTO	:	Commission of Land Transport Officials (South Africa)
CPT	:	Cone Penetrometer Test
CS	:	Cobblestone

D

DBM	:	Drybound macadam
DC	:	Design Class
DCP	:	Dynamic Cone Penetrometer
DF	:	Drainage Factor
DFID	:	UK Government's Department of International Development
DMT	:	Dilatometer Test
DBBM	:	Drybound Macadam
DS	:	Dressed Stone
DV	:	Design Vehicles

E

EF	:	Equivalency Factor
eg	:	For example (abbreviation for the Latin phrase exempli gratia)
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Management Plan
ENS	:	Engineered Natural Surfaces
EOD	:	Environmentally Optimised Design
ERA	:	Ethiopian Roads Authority
ERTTP	:	Ethiopian Rural Travel and Transport Programme
esa	:	Equivalent standard axles
EVT	:	Equiviscous Temperature

F

FACT	:	Fine Aggregate Crushing Test
FED	:	Final Engineering Design

G

g/m²	:	Grams per Square Metre
GDP	:	Gross Domestic Product
GM	:	Grading Modulus
gTKP	:	Global Transport Knowledge Partnership
GVW	:	Gross Vehicle Weight

H

ha	:	Hectare
HDM 4	:	World Bank's Highway Design and Maintenance Standards model
HIV	:	Human immunodeficiency virus
HPS	:	Hand Packed Stone
HVR	:	High Volume Road

I

ICB	:	International Competitive Bidding
ICT	:	Information Communication Technology
IDA	:	International Development Agency
ie	:	That is (abbreviation for the Latin phrase id est)
ILO	:	International Labour Organisation
IMT	:	Intermediate Means of Transport
IRR	:	Internal Rate of Return
ITB	:	Instructions to Bidders

K

km	:	Kilometre
km²	:	Square Kilometre
km/h	:	Kilometres per hour
km/hr	:	Kilometres per hour

L

LIC	:	Labour Intensive Construction
LVR	:	Low Volume Road

M

m	:	Metre
m²	:	Square Metre
m³	:	Metres Cubed
MCB	:	Mortared Clay Brick (fired)
MCS	:	Mortared Cobblestones
MDS	:	Mortared Dress Stone
Mesa	:	Million equivalent standard axles
mg/m³	:	Milligram per metre cubed
mm	:	Millimetre
mm²	:	Square Millimetre
mm³	:	Millimetres Cubed
m/s	:	Metres per second
MC	:	Medium Curing
MoFED	:	Ministry of Finance and Economic Development
MPa	:	megapascal (a unit of pressure equal to 1000 kilopascals (kPa), commonly used in the building industry to measure crushing pressure of bricks)
MS	:	Mortared Stone

MSSP	:	Mortared Stone Setts or Pavé
MWUD	:	Ministry of Works and Urban Design

N

NBP	:	Non-Bituminous Pavement
NCB	:	National Competitive Bidding
NCT	:	National Competitive Tendering
NGO	:	Non-Government Organisation
nm	:	Nanometre
NMT	:	Non-Motorised Transport
NRC	:	Non-reinforced concrete
NRCP	:	Non-reinforced concrete pavement

O

OMC	:	Optimal Moisture Content
ORN	:	Overseas Road Note
ORRA	:	Oromiya Regional Roads Authority

P

PCU	:	Passenger Car Unit
PDM	:	Pavement Design Manual
Pen.	:	Penetration
PI	:	Plasticity Index
PM	:	Pressure Meter
PPA	:	Public Procurement Agency
PPP	:	Public Private Partnership
PSD	:	Particle Size Distribution
PSNP	:	Productive Safety Net Programme

R

R	:	Radius
RC	:	Reinforced concrete
Ref	:	Reference (Part C, Page 13)
RFP	:	Request for Proposals
RRA	:	Regional Road Authority
RS	:	Road Safety
RSC	:	Research Steering Committee
RTS	:	Road Transport Service

S

SADC	:	Southern Africa Development Community
SBL	:	Sand Bedding Layer
SDMS	:	Surfacing Decision Management System
SE	:	Super Elevation
SMEs	:	Small and Medium Enterprises
SSP	:	Stone Setts or Pavé

T

TBA	:	To Be Advised
Tc	:	Time of Concentration
ToR	:	Terms of Reference
TRL	:	Transport Research Laboratory

U

UK	:	United Kingdom
USA	:	United States of America
USCS	:	Unified Soil Classification System

USD	:	United States Dollar
UTRCP	:	Ultra Thin Reinforced Concrete Pavement

V

VI	:	Impinging Velocity
VAVE	:	Average Velocity
VP	:	Parallel Velocity
vpd	:	vehicles per day
VOCs	:	Vehicle Operating Costs
VST	:	Vane Shear Test

W

WBM	:	Waterbound Macadam
WC	:	Wearing Course

GLOSSARY OF TECHNICAL TERMS

Aggregate (for construction)
A broad category of coarse particulate material including sand, gravel, crushed stone, slag and recycled material that forms a component of composite materials such as concrete and asphalt.

Asphalt
A mixture of inert mineral matter, such as aggregate, mineral filler (if required) and bituminous binder in predetermined proportions.

Atterberg limits
Basic measures of the nature of fine-grained soils which identify the boundaries between the solid, semi-solid, plastic and liquid states.

Binder, Bituminous
Any bitumen based material used in road construction to bind together or to seal aggregate or soil particles.

Binder, Modified
Bitumen based material modified by the addition of compounds to enhance performance. Examples of modifiers are polymers, such as PVC, and natural or synthetic rubbers.

Bitumen
A non-crystalline solid or viscous mixture of complex hydrocarbons that possesses characteristic agglomerating properties, softens gradually when heated, is substantially soluble in trichlorethylene and is obtained from crude petroleum by refining processes.

Bitumen, Cutback
A liquid bitumen product obtained by blending penetration grade bitumen with a volatile solvent to produce rapid curing (RC) or medium curing (MC) cutbacks, depending on the volatility of the solvent used. After evaporation of the solvent, the properties of the original penetration grade bitumen become operative.

Bitumen, Penetration Grade
That fraction of the crude petroleum remaining after the refining processes which is solid or near solid at normal air temperature and which has been blended or further processed to products of varying hardness or viscosity.

Bitumen emulsion
An emulsion of bitumen and water with the addition of an emulsifier or emulsifying agent to ensure stability. Conventional bitumen emulsion most commonly used in road works has the bitumen dispersed in the water. An invert bitumen emulsion has the water dispersed in the bitumen. In the former, the bitumen is the dispersed phase and the water is the continuous phase. In the latter, the water is the dispersed phase and the bitumen is the continuous phase. The bitumen is sometimes fluxed to lower its viscosity by the addition of a suitable solvent.

Bitumen Emulsion, Anionic
An emulsion where the emulsifier is an alkaline organic salt. The bitumen globules carry a negative electrostatic charge.

Bitumen Emulsion, Cationic
An emulsion where the emulsifier is an acidic organic salt. The bitumen globules carry a positive electrostatic charge.

Bitumen Emulsion Grades

Premix grade: An emulsion formulated to be more stable than spray grade emulsion and suitable for mixing with medium or coarse graded aggregate with the amount smaller than 0.075mm not exceeding 2%.

Quick setting grade: An emulsion specially formulated for use with fine slurry seal type aggregates, where quick setting of the mixture is desired.

Spray grade: An emulsion formulated for application by mechanical spray equipment in chip seal construction where no mixing with aggregate is required.

Stable mix grade: An emulsion formulated for mixing with very fine aggregates, sand and crusher dust. Mainly used for slow-setting slurry seals and tack coats.

Cape Seal

A single application of binder and stone followed by one or two applications of slurry.

Cement (for construction)

A dry powder which on the addition of water and other additives, hardens and sets independently to bind aggregates together to produce concrete.

Chip Seal, Single

An application of bituminous binder followed by a layer of stone or clean sand. The stone is sometimes covered with a fog spray.

Chip Seal, Double

An application of bituminous binder and stone followed by a second application of binder and stone or sand. A fog spray is sometimes applied on the second layer of aggregate.

Collapsible soil

Soil that undergoes a significant, sudden and irreversible decrease in volume upon wetting.

Complimentary Interventions

Actions that are implemented through a roads project which are targeted toward the communities that lie within the influence corridor of the road and are intended to optimise the benefits brought by the road and to extend the positive, and mitigate the negative, impacts of the project.

Concrete

A construction material composed of cement (commonly Portland cement) as well as other cementitious materials such as fly ash and slag cement, aggregate (generally a coarse aggregate such as gravel or crushed stone plus a fine aggregate such as sand), water, and chemical admixtures.

Concrete Block Paving

A course of interlocking or rectangular concrete blocks placed on a suitable base course and bedded and jointed with sand.

Crushed Stone

A form of construction aggregate, typically produced by mining a suitable rock deposit and breaking the removed rock down to the desired size using crushers.

Design speed

The maximum safe speed that can be maintained over a specified section of road when conditions are so favourable that the design features of the road govern the speed.

Dispersive soil

Soil in which the clay particles detach from each other and from the soil structure in the presence of water and go into suspension.

Distributor
A vehicle comprising an insulated tank with heating and circulating facilities and a spray bar capable of applying a thin, uniform and predetermined layer of binder.

Expansive soil
Typically clayey soil that undergoes large volume changes in direct response to moisture changes.

Filler
Mineral matter composed of particles smaller than 0.075mm.

Fog Spray
A light application of diluted bitumen emulsion to the final layer of stone of a reseal or chip seal or to an existing bituminous surfacing as a maintenance treatment.

Gravel
A naturally-occurring, weathered rock within a specific particle size range. In geology, gravel is any loose rock that is larger than 2mm in its largest dimension and not more than 63mm.

Kabele
Administrative division in Ethiopia equivalent to sub-district or ward. Smallest administrative unit in Ethiopia.

Labour Intensive Construction
Economically efficient employment of as great a proportion of labour as is technically feasible throughout the construction process to produce the standard of construction as demanded by the specification and allowed by the available funding. Substitution of equipment with labour as the principal means of production.

Low Volume Road
Roads carrying up to about 300 vehicles per day and less than about 1 million equivalent standard axles over their design life.

Otta Seal
A carpet of graded aggregate spread over a freshly sprayed hot bituminous binder.

Prime Coat
A coat of suitable bituminous binder applied to a non-bituminous granular pavement layer as a preliminary treatment before the application of a bituminous base or surfacing. While adhesion between this layer and the bituminous base or surfacing may be promoted, the primary function of the prime coat is to assist in sealing the surface voids and bind the aggregate near the surface of the layer.

Reseal
A surface treatment applied to an existing bituminous surface.

Rejuvenator
A material (which may range from a soft bitumen to petroleum) which, when applied to reclaimed asphalt or to existing bituminous surfacing, has the ability to soften aged, hard, brittle binders.

Seal
A term frequently used instead of "reseal" or "surface treatment". Also used in the context of "double seal" and "sand seal" where sand is used instead of stone.

Selected layers
Pavement layers of selected gravel materials used to bring the subgrade support up to the required structural standard for placing the subbase or base course.

Site Investigation
Collection of essential information on the soil and rock characteristics, topography, land use, natural environment, and socio-political environment necessary for the location, design and construction of a road.

Slurry
A mix of suitably graded fine aggregate, cement or hydrated lime, bitumen emulsion and water, used for filling the voids in the final layer of stone of a new surface treatment or as a maintenance treatment (also referred to as a slurry seal).

Slurrybound Macadam
A surfacing layer constructed where the voids in single-sized stone skeleton are filled using bituminous slurry.

Subgrade
The native material underneath a constructed road pavement.

Surface Treatment
A general term incorporating chip seals, micro surfacing, fog sprays or tack coats.

Surfacing
The layer with which traffic makes direct contact.

Tack Coat
A coat of bituminous binder applied to a primed layer or to an existing bituminous surface as a preliminary treatment to promote adhesion between the existing surface and a subsequently applied bituminous layer.

Ultra-thin Reinforced Concrete Pavement (UTRCP)
A layer of concrete, 50 mm thick, continuously reinforced with welded wire mesh.

Wearing Course
The upper layer of a road pavement on which the traffic runs and is expected to wear under the action of traffic.

Waterbound Macadam
A pavement layer constructed where the voids in a large single-sized stone skeleton are filled with a fine sand.

Wereda
Administrative division in Ethiopia equivalent to district.

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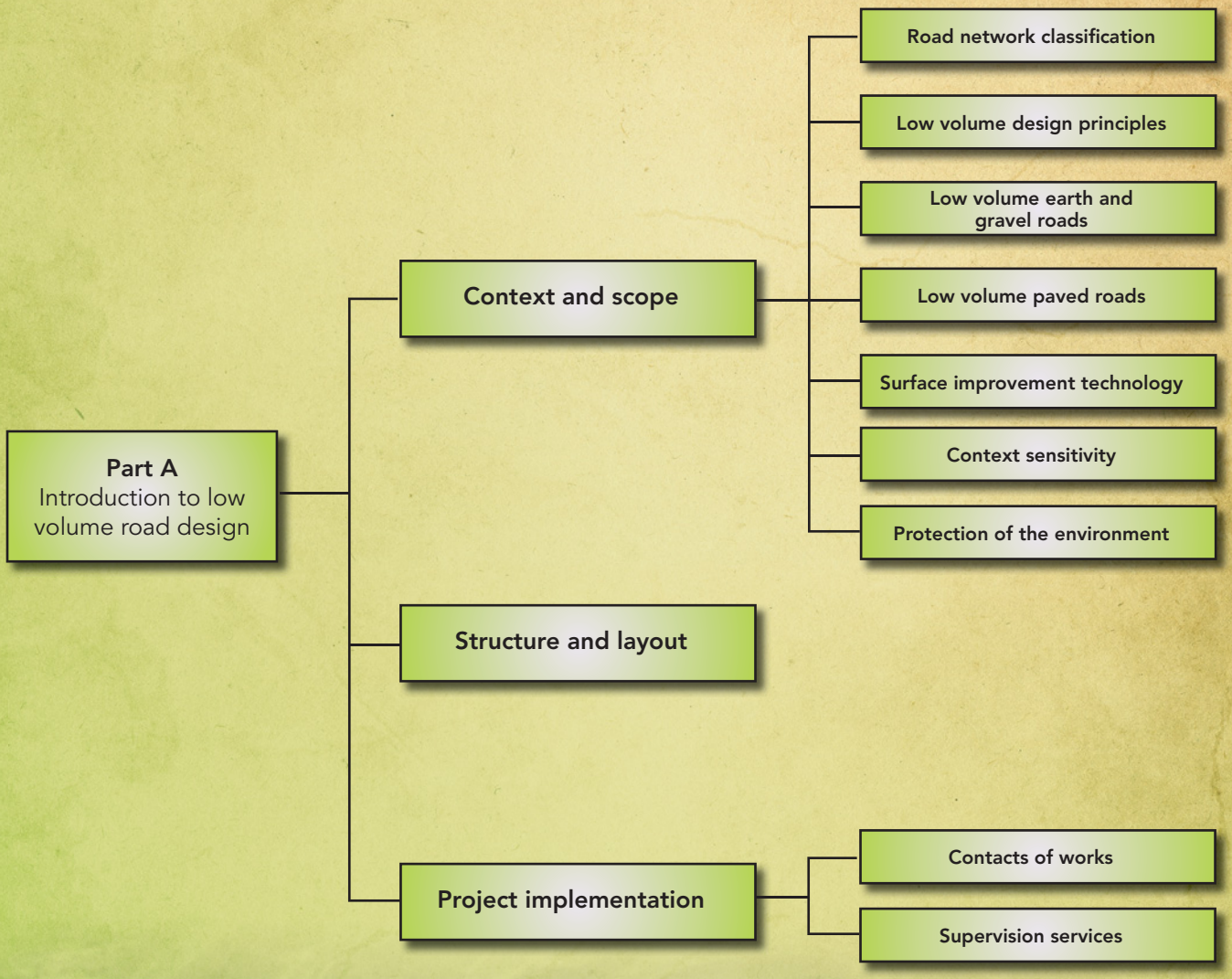
PART A

INTRODUCTION TO LOW VOLUME ROAD DESIGN



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1. CONTEXT AND SCOPE OF THE LOW VOLUME ROADS MANUAL

This Low Volume Roads Manual promotes rational, appropriate and affordable designs for low volume roads in Ethiopia. In doing so it aims at making cost effective and sustainable use of local resources. The Manual reflects local experience and advances in low volume road technology gained in Ethiopia and elsewhere.

Application of appropriate design standards for low volume roads in Ethiopia aims to optimise construction and maintenance costs and meet requirements to:

- Improve the economic and social well being of rural communities and access to social and other services;
- Facilitate inclusion of different ethnic and other groups in society;
- Lower road user costs and promote socio-economic development, poverty reduction, trade growth and wealth creation in rural areas;
- Protect and manage non-renewable natural resources and reduce import dependency.

This manual is intended for use by roads practitioners responsible for the design of low traffic earth, gravel or paved roads in Ethiopia. It is appropriate for roads which, over their design life, are required to carry an average of up to about 300 vehicles per day, and less than about 1.0 million equivalent standard axles (Mesa) in one direction. The Manual complements and links to the "Pavement Design Manual – Volume 1 - Flexible Pavements" and is accompanied by separate volumes dealing with Technical Specifications, Drawings and appropriate level Bidding Documents.

The client for the low volume road works could be a Wereda Administration, a Regional Roads Authority or the Ethiopian Roads Authority. The client could also be a local level administration such as a Kebele Administration, community organisation or cooperative. Road works, whether undertaken by a contractor, through an in-house capability or by community will require a design. This design will work towards satisfying a national standard set for a particular type of road. The degree of sophistication of the design will in general increase as the standard of the road increases. However, this does not mean that unpaved earth or gravel roads are any easier to design than a first generation low volume sealed road. Often it is quite the contrary.

The road design engineer is normally supported by a team of individuals, with varying specialities, and equipped to deal with all aspects of the road design. The job of the design team is to provide a robust technical design (geometric, drainage and pavement) and to reflect this in the instructions to bidders, conditions of particular application, the specifications, the bills of quantities and the detailed drawings. The design team should also include (or consult) environmentalists and sociologists for additional specialist inputs.

The general approach to the design will be guided by the client and will build on information and data collected during the project pre-feasibility and feasibility stages. The client will have a budget in mind for the works, the location and route will be known in outline, and the preferred approach to the works will also be known, for example labour or equipment based. The client may also have views and guidance on apportioning works and contract size, technical issues, social, environmental and time constraints. The job of the road design engineer will then be to develop the project within and around these boundaries and limitations, whilst at the same time alerting the client to issues and problems that may limit or require adjustment of expectations.

The approach to the design of low volume roads follows the general principles of any good road design practice. There are, however, subtle differences from the traditional road design practice. This manual sets out to provide the design engineer with the requisite tools that will provide the client with an optimised design based on the financial, technical and other constraints that define the project.

Optimising a design requires a multi-dimensional understanding of all of the project elements and in this respect all design elements become context specific. The design team therefore needs to be able to

work outside their normal areas of expertise and to understand implications of their recommendations or decisions on all other elements of the design.

The successful design of low volume roads relies on:

- A full understanding by the design engineer of the local environment (natural 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 thinking related to road design;
- A client who is open and responsive to innovation;
- Guaranteed routine and periodic maintenance.

There is an onus on the design engineer to provide a road that meets the expected level of service. Design engineers are traditionally conservative and build in factors of safety that cater for their perceptions of risk and extremes of caution. This approach prevents the application of innovation, uses scarce or inappropriate resources and results in high financial costs for the client and the country. There is also often a temptation to provide or upgrade roads to a future level of service not justified by the economic or other project projections; or road user requirements. This type of approach absorbs available resources and prevents extension of access. It is the role of the design engineer to properly represent the clients and country's interests.

The level of attention and engineering judgement required for optimal provision of low volume roads is no different and in most cases is higher than that required for the provision of other roads. The design engineer needs to draw on all of his engineering skills, judgement and local experience if appropriate designs are to be developed without incurring unacceptable levels of risk. This manual will assist the engineer in that task.

The Manual is fully compatible with the ERA Standard Specifications for Road Works, the ERA 2011 series of design manuals for higher volume road, and ERA's Standard Bidding Documents.

1.1 Road network classification

The functional classification of roads in Ethiopia is based on five classes:

- **Trunk roads:** roads linking Addis Ababa to centres of international importance and to international boundaries;
- **Link roads:** connecting centres of national and international importance such as principal towns and urban centres;
- **Main access:** connecting centres of provincial importance;
- **Collectors:** connecting locally important centres to each other or to a more important centre or to a higher class road; and
- **Feeder roads:** connecting minor centres such as a market to other parts of the network.

Low volume roads can be represented in all five of these functional classes.

Roads in Ethiopia can be further divided into three categories depending on ownership and the authority responsible for them. These are:

- Federal (the responsibility of the Ethiopian Roads Authority);
- Regional (the responsibility of the Regional or Rural Roads Authorities); and
- Other rural roads (the responsibility of local authorities at Wereda or Kebele level or communities).

ERA is responsible for major roads falling into the higher design classes, predominantly DC5 and above, but also has a substantial stock of roads below DC5. Regional and local authorities are responsible for roads in classes DC4 – DC1.

Figure A.1.1 shows the definitive classification of roads in Ethiopia based on geometric standards with the appropriate level of service as defined below Figure A.1.1.

Road Functional Classification						Geometric Standards	Level of Service	AADT
				TRUNK	HIGH VOLUME	DC8	A	>10,000
			LINK			DC7		3,000 - 10,000
						DC6	B	1,000 - 3,000
		MAIN ACCESS				DC5		300 - 1,000
	COLLECTOR				LOW VOLUME	DC4	C	150 – 300
FEEDER						DC3		75 – 150
						DC2		25 – 75
						DC1	D	<25
						Track		

Figure A.1.1: Road classes in Ethiopia

Level A: The highest level of service. Traffic is free flowing, with the volumes and types of traffic easily accommodated. Safety is a high priority. Design speed is very important and takes precedence over topographic constraints.

Level B: Traffic may not flow smoothly in all situations. Safety is a high priority, but some safety controls may need to be enforced. Design speed is important, but topography may dictate some design changes and controls.

Level C: The efficiency of traffic movement and flow is not a limiting factor. Traffic will be accommodated, but some design controls may need to be applied. Safety provisions are adapted to lower and variable speed scenarios. The topography will dictate alignment and the design speed.

Level D: Service level is geared to provision of access rather than efficiency. Design standards for water-crossings may allow service interruption and some roads may even be closed to protect these assets. Other design standards for geometrics, surfacing and safety will reflect lower speed environments and access requirement.

The density of roads in most areas of Ethiopia is relatively low and many existing low volume roads are relatively long (>25km). Alternative routes are often long or non-existent and the consequences of disruption are high. It is prudent therefore to adopt design standards that provide an appropriate level of reliability and service commensurate with the functional characteristics of the road.

While there are exceptions to every rule, low volume roads in Ethiopia can be considered as roads carrying less than 300vpd and generally of DC4 standard or below and meeting C or D service level criteria. The majority of roads in Ethiopia carry relatively low levels of traffic, and most carry less than

about 300 vehicles per day. Such roads are referred to as "low-volume" roads in this manual and all are an essential component of the road system. Their importance and reach extends to all aspects of the economic and social development of rural communities and the country at large.

1.2 Low volume road design principles

Ethiopia is a country of great geographical, geological and climatic diversity. Altitudes range from the highest peak at Ras Dejen, 4,620 meters above sea level, down to the Afar Depression at about 110 meters below sea level. Ethiopia's high plateaus and mountain ranges, usually above 1500 meters are characterised by precipitous edges and dissection by numerous rivers and streams. These areas constitute about 45 percent of the total area and are inhabited by close to 80 percent of the population.

Below 1500 meters are the lowland areas, located in the north-west, east and south. The vast majority of these areas support nomadic and semi-nomadic pastoralism. The descent to the southwest and west leads to the semi–humid lowlands. Climatic regions range from arid, tropical rainy to temperate rainy areas.

Soils are highly variable and often problematic, available materials for construction can be very variable or scarce and involve long haulage.

Hence, traditional engineering, and traditional road engineering in particular, is challenging in the face of such diversity. For low volume road provision the challenges can be even greater. Low volume roads provide important links from homes, villages and farms to markets and offer communities access to health, education and other services. These roads also provide important links between Kebele and Wereda centres and the Federal road network. Given their importance, design engineers need to work with and around such challenges. Clients also need to be flexible and adaptable, if low volume roads are to be provided at reasonable cost.

Typically in Ethiopia, low volume roads are unpaved with a gravel or earth wearing surface. Very few are in good condition and can provide the level of all-weather access that is required. Budgets for the improvement and maintenance of these roads are constrained. In facing the challenge of improving the low volume road network, the application of the conventional planning, design, construction and maintenance philosophies used for higher traffic roads is unlikely to provide an optimal solution.

In determining cost-effective solutions for the provision of low volume roads it is important to understand the mechanics of how the road deteriorates in the first place. Deterioration of the existing unpaved low volume roads in Ethiopia is governed by the type of material used on the surface (gravel to soil); the strength of the underlying soil (soft, erodible and/or expansive), the type and action of traffic (heavy vehicle to pedestrian) and probably most importantly, the influence of the "road environment". The term "road environment" includes both the natural or bio-physical environment and the human environment. It includes the interaction between the different environmental factors and the road structure. Some of these factors are uncontrollable, such as those attributable to the natural environment, including the interacting influence of climate (eg wind, rainfall and intensity), local hydrology and drainage, terrain and gradient. Collectively, these will influence the performance of the road and the design approach needs to recognise such influence by providing options that minimise the negative effects. Others factors, such as the construction and maintenance regime; safety and environmental demands; and the extent and type of traffic are largely controllable and can be more readily built into the design approach.

Typical road environment factors are presented in Figure A.1.2 and covered in more detail in Part D, Chapter 6 of the Manual.

Figure A.1.2: Framework for sustainable provision of low volume roads

1.3 Low volume earth and gravel roads

Surface materials, where these are present, need to resist wear and abrasion in dry weather and promote surface drainage and run-off in wet weather. Under traffic they need to resist whip off, dust generation and be stable enough when compacted to resist deformation. The compacted material needs to resist erosion and scour.

The nature and strength of the underlying soil is critical in determining the performance of low volume roads, particularly in periods of wet weather. Many rural roads are characterised by deep rutting, where the road formation is not strong enough to support the traffic loads. Some roads have loose and/or stony materials on the surface, leading to dusty, rough and/or slippery conditions. Potholes create difficult and unsafe surfaces. Severe erosion and scouring may prevent access by any form of motorised, and many types of intermediate, transport. Transverse scouring can start at the edge or on the side slope of the road and work its way to the centre of the carriageway. Longitudinal scour occurs where water flows against the direction of road crossfall. Inadequate scour protection in drainage ditches may lead to serious erosion, dangerous conditions for road users, local access restrictions, and loss of valuable agricultural land along the road.

Rural access may be prevented for long periods during the rains when streams and rivers start to flow. In some situations wash-aways may occur. When the rains have eased or stopped the same points may be subject to saturation and ponding. This weakens the underlying soils and any movement on the surface can churn up the surface causing deep rutting and the bogging down of vehicles.

Plate A.1.1: Typical access problems

This problem is worsened in areas where there is a prevalence of expansive, black cotton soils. These soils have high agricultural potential, but become weak and slippery when wet. They often cannot support even the lightest vehicles. Where gravel is placed directly over this material it may rut under the influence of traffic and mix into the weak soil below.

Vehicle operating costs (VOCs) are high on roads with high roughness and restricted access. VOCs include repairs, maintenance, fuel and tyre replacement. The consequence is that transport operators tend to avoid roads with high roughness and other defects forcing people to walk long distances to reach the nearest point where transport services are prepared to operate.

Dust is often overlooked as a problem on unpaved roads. It is caused by the action of traffic and wind. Unpaved roads lose fine material which can travel over 100 metres from the road. The dust affects other road users, pedestrians and school children, houses, shops and crops near the road. Roads in dry areas can lose up to 33 tonnes of surface fines per kilometre per year. Dust has significant and costly social (cleanliness), health (eye and respiratory hazards), environmental (crop and natural habitat damage) and economic (vehicle and equipment damage, pedestrian and vehicle safety) consequences. Approaches to alleviate dust problems, particularly in populated areas are offered in the Manual.

Gravel for road works is a non-renewable natural resource. On unpaved roads it is used as a sacrificial layer and must be periodically replaced. Optimal materials for gravel surfaced roads are not commonly found in Ethiopia, and it is possible to lose up to 150mm of gravel per year depending on conditions. Gravel roads require a continuous cycle of reshaping and regravelling to maintain the required running surface and the desired level of service. The type of materials prevalent in Ethiopia, the nature of the climate and the terrain presents significant challenges to achieving this type of maintenance. Screening and blending techniques are available to improve the properties and such techniques are described in the Manual.

The major technical challenges for unpaved roads are to provide durable and functional water crossings, surfacing with materials that provide the desired and necessary level of service and to provide effective maintenance management. These challenges are recognised in the Manual and in many cases options and solutions are offered to mitigate and manage problems.

1.4 Low volume paved roads

The design manual draws on international research carried out over several decades. This research was carried out by a number of research organisations in collaboration with national road authorities, including the Ethiopian Roads Authority. Much of the research was aimed at deriving local specifications, designs and techniques for improving the cost-effective provision of low volume roads sealed with a bituminous or alternative, non-bituminous surfacing and advanced thinking on provision of more appropriate geometric, drainage and pavement design standards. Innovative construction techniques and methods were identified that optimised the use of local labour, introduced intermediate equipment techniques and improved opportunities for the local private sector to participate in road construction and maintenance.

The research questioned existing paradigms associated with paved surfacing design for low volume roads. This research, combined with local experience, provided a basis for understanding how such roads deteriorate leading to the development of revised standards, specifications and design methods that make better use of locally available materials and demonstrate an effective range of viable bituminous and non-bituminous surfacing technologies.

The approaches adopted for the design of low volume paved roads differs in a number of fundamental respects from roads carrying higher traffic volumes. In particular, the relative influences of road deterioration factors are significantly different for low volume roads compared with higher volume roads. A critical observation is that for sealed roads, carrying below about 1.0 Mesa pavement deterioration was controlled mainly by how the road responded to environmental factors, such as moisture changes in the pavement layers, fill and subgrade and to the effects of age hardening of bituminous surfacings. The appropriate design options for low volume roads therefore need to be responsive to a wider range of factors captured in the road environment, the most critical being the internal and external drainage.

The role of the design engineer is to recognise and design to these parameters and optimise the design to the expected performance. This is known as an environmentally optimised design (EOD) approach. EOD takes account of road environment changes along the alignment and the design responds to these changes (for more details see Part D, Section 6.13).

1.5 Surface improvement technology

Gravel and earth roads are particularly vulnerable to the effects of the road environment. A range of more durable surfacing options, other than gravel or earth are available for low volume roads. These include thin bituminous surfacings, and non-bituminous surfacings such as cobbles, hand packed stone and even thin concrete. The selection, design and use of the various surfacing options are described in detail in this manual in Part D, Chapter 7 with design standards presented in Part B, Chapter 3.4.

Improved surfacings may be provided for the entire length of a road, or only on the most vulnerable sections. The approach may include dealing only with individual critical sections (weak or vulnerable sections; roads through villages or settlements) on a road link (spot improvements), or providing a total whole rural link design, which could comprise different design options along its length.

The choice of surfacing type, and when to use it, involves a trade-off between initial cost, level of service and maintenance requirements. Cobblestone may use locally available resources and require very little maintenance, but it gives a relatively rough riding surface. Surface dressings provide smoother riding surfaces but may require more expensive earthworks and pavement layers, as well as imported bitumen, specialised equipment and skilled operators. Appropriate selection will be driven to some extent by the service level.

Surface dressings should not be constructed where there is no capacity for routine maintenance, including pothole repairs and crack sealing, as well as periodic re-sealing. Edge break is a common problem on sealed roads due to vehicles and pedestrians moving on and off the road, and needs to be controlled through appropriate road width, provision of stopping places, and kerbing.

The challenge for the design engineer for a low volume road is to achieve the required level of service, using appropriate engineering approaches and to minimise costs over the whole life of the road. This should be done in a context sensitive way that recognises the needs of the client, the road environment and the prevailing maintenance management regime.

1.6 Context sensitivity

In addition to ensuring that the design developed is technically appropriate and is within the financial envelope, the design engineer needs to bear in mind other factors that could influence the success of the low volume road design approach, its implementation and its long term sustainability.

This requires a broadly focused, multi-dimensional and context sensitive approach in which a number of other influential factors are considered, illustrated in Figure A.1.3.

1.6.1 Political support

Demand for low volume road provision needs to be framed under a national policy driven by government and should be supported at the highest level. The cross-sectoral influence of low volume road provision and its role in under-pinning other sectoral development strategies and poverty alleviation programmes should be highlighted, quantified and understood.

The approach adopted for low volume road provision should complement national plans, policies and strategies and should be responsive to wider needs and demands, including:

- The social and economic goals of poverty alleviation and development;
- Increasing rural accessibility;
- The use of appropriate technology, promotion of the domestic construction industry and employment creation;
- Protection of the environment;
- Cost minimisation and improved efficiency.

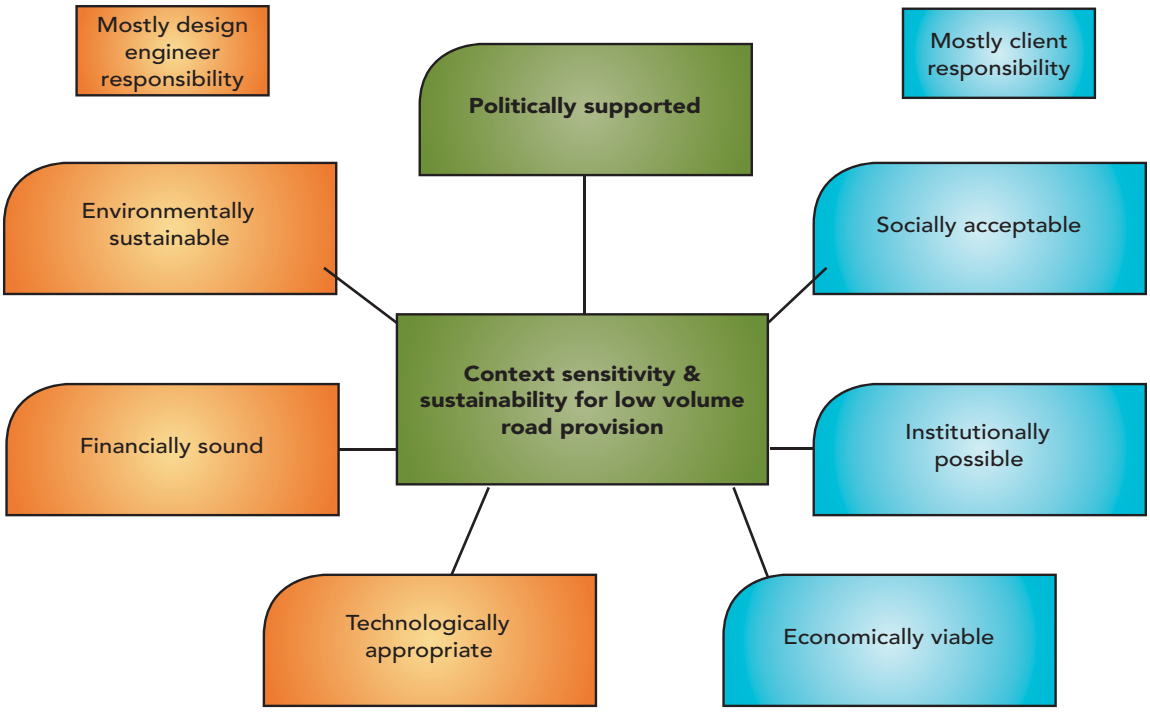

Figure A.1.3: Framework for sustainable provision of low volume roads

There is a need to maintain dialogue with political and public stakeholders in order to highlight the advantages of design approaches and alternative, often unfamiliar, solutions selected for low volume road provision. The language used for advocacy should be carefully chosen and should avoid negative connotations such as "low standard"; "low cost" and "marginal".

1.6.2 Social acceptance

Provision of low volume rural road networks should be managed in a way that:

- Ensures community participation in planning and decision making;
- Eliminates gender bias and promotes participation by women in the road sector;
- Promotes activities and investment for sustainable livelihoods (including Complementary Interventions shown in Part C);
- Promotes road safety in all aspects of low volume road provision.
- Supports cost-effective labour-based and intermediate equipment methods of construction and maintenance; and
- Minimises resettlement and mitigates unavoidable resettlement through appropriate compensation.

1.6.3 Institutional capacity

Road authorities and clients should:

- Promote institutional, economic and technical understanding in the provision and management of low volume roads;
- Promote commercial management practices;
- Develop a conducive environment for the development of national contractors;
- Ensure that design, construction and maintenance approaches for low volume roads are represented on all tertiary civil engineering training curricula.

1.6.4 Technology choice

Technologies for designing, constructing and maintaining low volume roads should:

- Employ appropriate design standards and specifications;

- Utilise intermediate equipment technology options and reduce reliance on heavy equipment imports;
- Promote road construction and maintenance technologies that create employment opportunity;
- Use types of contract that support the development of domestic contractors and consultants;
- Be robust to the vagaries of climate and recognise potential impacts of a changing climate.

1.6.5 Economic viability

Economic appraisal for low volume roads should:

- Employ tools for low volume roads that should be capable of quantifying social, economic and environmental costs and benefits;
- Ensure investment decisions for low volume roads are based on an assessment of whole life costs.

1.6.6 Financially sound

Sustainable provision of low volume roads depends on the sustainable provision of funding to the sector in that:

- Roads should not be upgraded to engineered standards if funding is not in place for routine and periodic maintenance requirements.
- Designs should not be forwarded that require excessive allocation of maintenance resources.

1.6.7 Protection of the environment

The design and management of low volume roads should:

- Minimise the physical impacts of construction and maintenance activities on the natural environment;
- Take account of socio-cultural impacts (community cohesion);
- Minimise the carbon footprint;
- Optimise resource management and allow for recycling of non-renewable materials; and
- Minimise impacts and emissions that might contribute to climate change.

1.7 Protection of the environment

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- Minimise the physical impacts of construction and maintenance activities on the natural environment;
- Take account of socio-cultural impacts (community cohesion);
- Minimise the carbon footprint;
- Optimise resource management and allow for recycling of non-renewable materials; and
- Minimise impacts and emissions that might contribute to climate change.

2. STRUCTURE AND LAYOUT

The low volume road manual has been drafted with a view to it being fully adaptable for different clients. The Manual has application for roads at a federal level and administered by the Ethiopian Roads Authority, regional level for roads administered by the Regional and Rural Roads Authorities and district level for roads administered by district (Wereda /Kebele) administrations or communities. The document can cater for interventions that deal with individual critical areas on a road link (spot improvements) through to providing total rural road link designs. In this latter case, this could comprise different design options along the total length.

The Manual is divided into five parts:

- Part A provides an overview of the Manual, its application, context, use and introduces the philosophy of low volume road design.
- Part B sets out typical design controls that should be considered during the design process and the national design standards for low volume roads in Ethiopia. These are mandatory standards that must be adhered to by the engineer. Departures from these standards are only permitted in exceptional circumstances and with the prior approval of the relevant authorities.
- Part C describes how complementary interventions and activities can be introduced into the road works contract and how these can add value and impact to the project for the client and beneficiary communities, and users.
- Part D provides the engineering details and guidance on the application of the national standards for the design of low volume roads given in Part B.
- Part E provides the engineering details and guidance on the design of low level structures and water crossings for low volume roads.

The structure of the Manual is shown in Figure A.2.1.

The low volume road manual is comprehensive, in that it deals with the design standards and technicalities of all types of road (paved and unpaved), low level water crossing structures and socio-environmental aspects. The Manual deals with design standards for road geometry, earthworks, drainage, pavement structures and surfacing, with relevant approaches to route selection, site investigation, materials selection, testing and treatment, and the design of low level water crossings and structures for low volume roads.

The structure of the Manual is such that it allows client authorities (Federal, Regional and Wereda) to extract and use those parts of the Manual most appropriate to their individual set of circumstances. The complete document can be downsized to capture specific and appropriate aspects.

In terms of "road type", Wereda Administrations, Kebele committees, community organisations or cooperatives would generally be concerned with the design of low volume unpaved, earth and gravel roads. Regional Road Authorities and the ERA would be concerned with larger gravel roads and bituminous sealed roads. Part D of the Manual captures all of the design elements, approaches and aspects for each of these types of roads. The Manual deals with each of these road types and the national standards for particular road types are set out and explained in Part B. Part B can be used by the engineer or others who simply needs to look-up the values of the key parameters.

All authorities should find application for alternative surfacing technologies and spot improvement approaches (Part D) and for utilisation of low level water crossings (Part E). All authorities should also be interested to find application for complementary interventions and activities (Part C).

A clear understanding of the end users and their requirement for the Manual document is essential. The low volume road manual caters for a range of road type, from basic earth tracks to bituminous sealed roads. It is unlikely that one institution will cater for all standards of road and more likely that the document will have application across a number of different authorities, agencies and ministries. Bituminised and major gravel roads in Ethiopia are constructed and maintained by the Federal and Regional Roads Authorities. The Districts (Wereda) and sub-districts (Kebele) have substantial networks of unpaved

gravel and earth roads. Substantial kilometres of unpaved road are also provided through community programmes, cooperative ventures and by programmes operating through other line ministries, such as the Ministry of Agriculture. The Manual contains technical explanations of all the steps in deriving the standards for low volume roads related to specific environmental conditions. The Manual is structured to provide the building blocks for authorities to compile their own tailored document that is applicable to their prevailing circumstances.

Figure A.2.1: The structure of the Manual

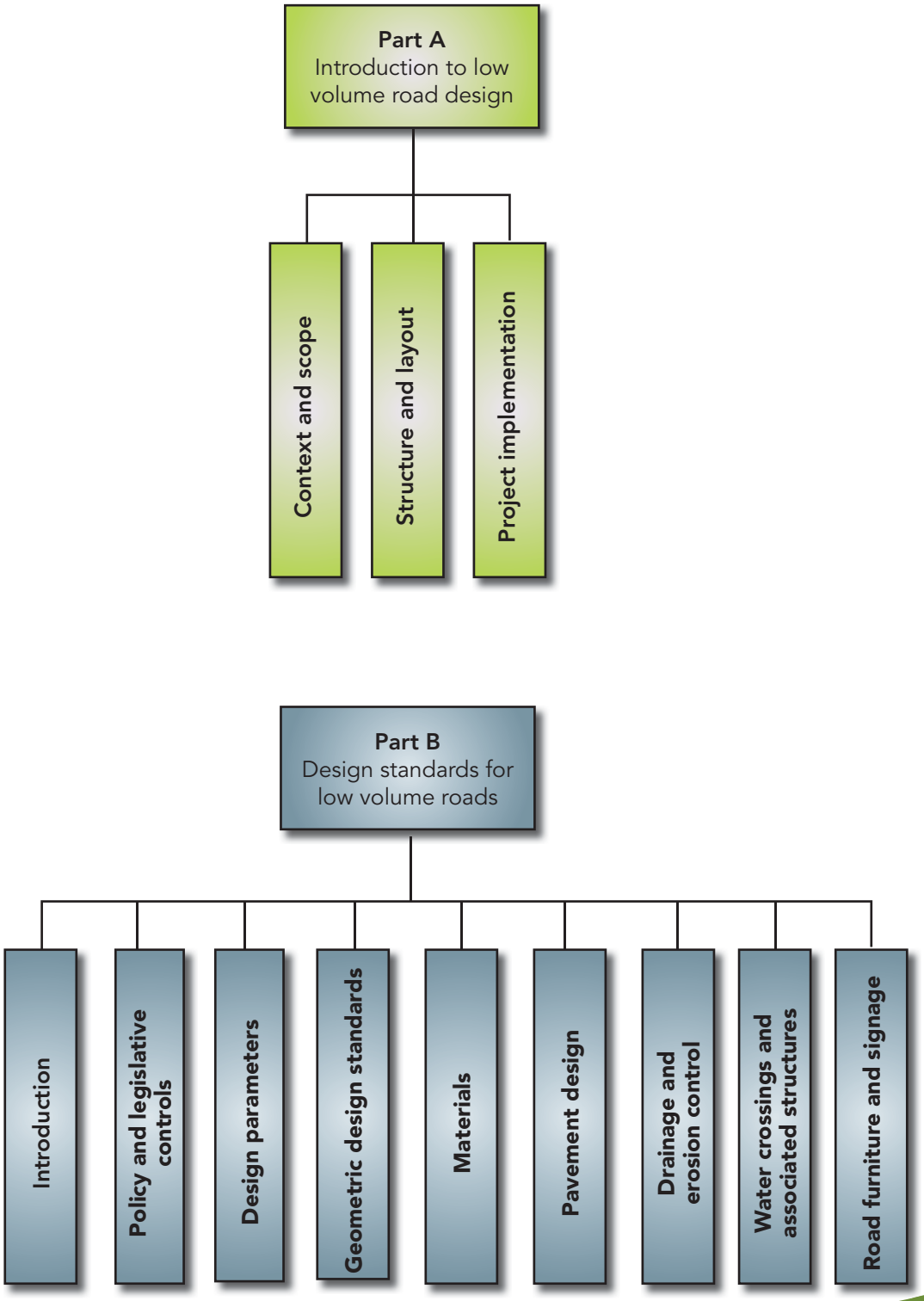
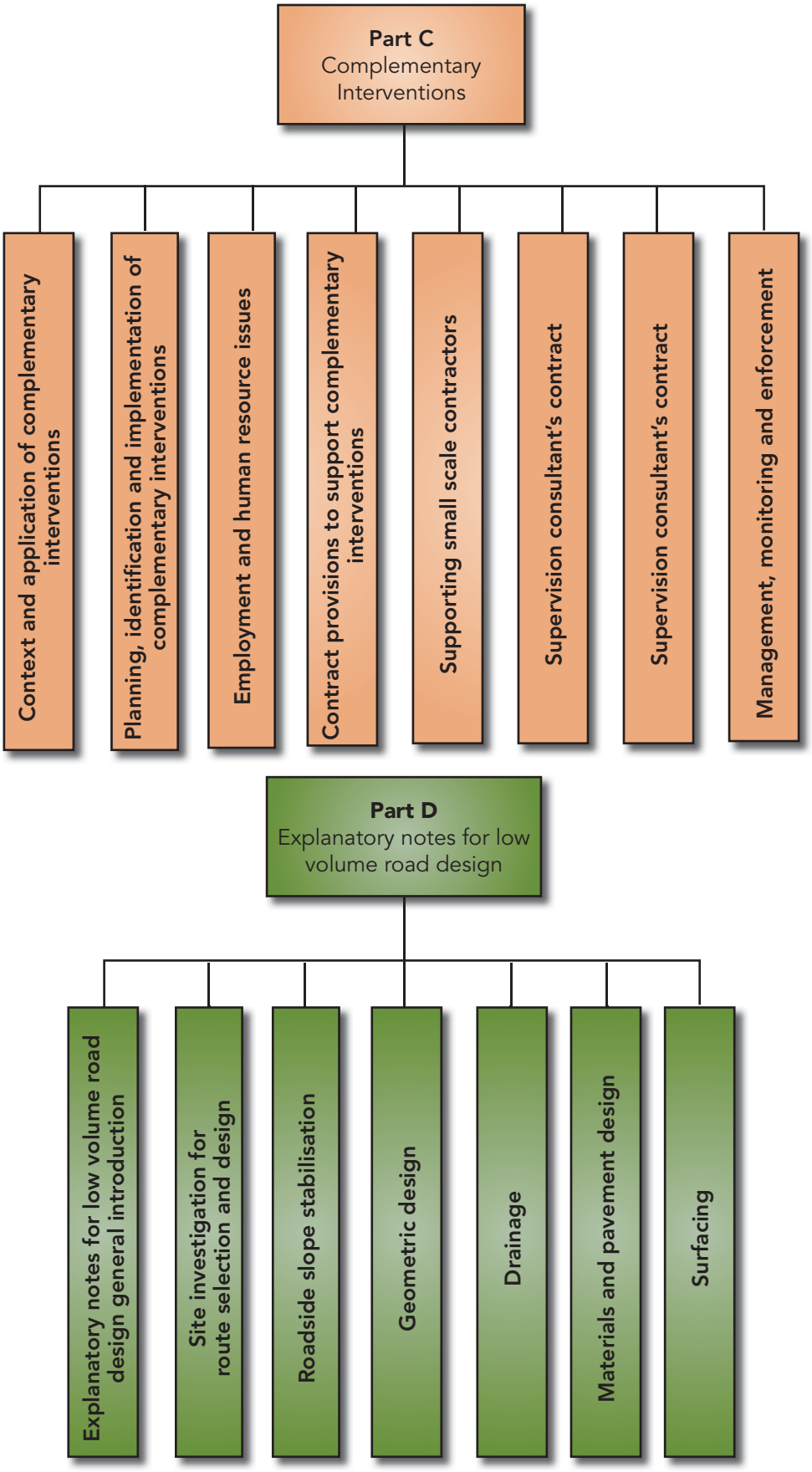


Figure A.2.1: The structure of the Manual (continued)



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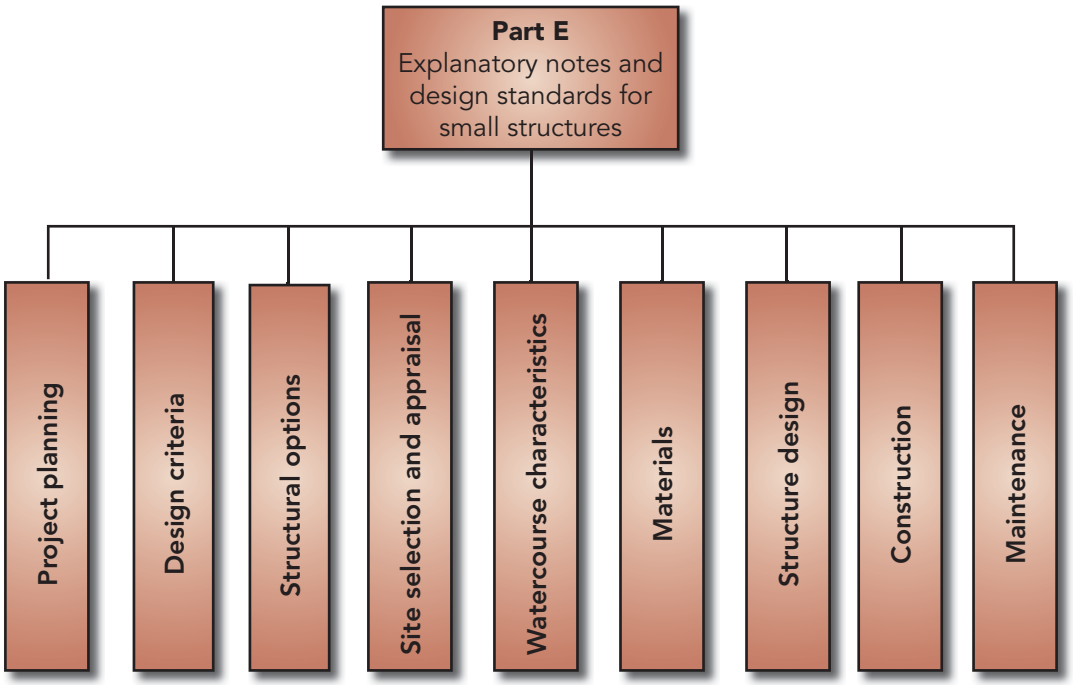

3. ROAD PROJECT IMPLEMENTATION

3.1 Contract of works

The key to successful execution of the low volume roads project will be to ensure clearly defined requirements and adequate provisions are included in all bidding and contract documents. A clear understanding of the requirements from both the works contractor and the supervising engineer is needed.

Bidding documents need to contain all of the information and provisions for the interested companies or organisations on all that is relevant to obtain the contract. The bidding document informs interested bidders on all of the procedures to be followed, documents to be submitted, the bid evaluation procedure and the award of contract.

Bidding documents need to provide the bidder with all essential information for successful completion of the project. The approach used for execution of low volume roads can differ in many respects from the traditional road provision approaches. For example, the client may favour labour-based approaches; the use of intermediate equipment; sub-contracting to empower small enterprises; and/or additional enhancements through complementary interventions (Part C). It is therefore important that the provisions within the bidding documents clearly reflect these preferences and adjust the provisions of the contract accordingly.

Failure to properly differentiate low volume road approaches can lead to complications during the bidding procedure or execution of the contract. Moreover, clear and well prepared bidding documents are essential to ensure that sufficient companies or organisations are confident to bid for works.

In order to facilitate preparation of documents a series of model bidding documents have been prepared for use with works of differing complexity. These model documents which will vary in complexity depending on the maximum contract value include:

- Standard Bidding Documents For Major Work, International Competitive Bidding (ICB) and National Competitive Bidding (NCB) versions – Unlimited Contract Value;
- Standard Bidding Document for Intermediate Works (based on PPA 2006) - – both ICB and NCB versions - Maximum contract value USD10 Million;
- Standard Bidding Document for the Procurement of Minor Works – Maximum contract value USD3 Million;
- Standard Bidding Document for the Procurement of Micro Works – Maximum contract value USD300,000.

For each of the above documents a User Guide has been developed to provide guidance to the Client or Employer organisation and to the design consultant who may be employed in preparing the documents.

In nearly all cases local authorities would be concerned with contract values below USD10M, whilst ERA and Regional or Rural Road Authorities could utilise all available bidding documents.

The main issues for a bidder/contractor is to fully understand the scope of all the works, including any complementary interventions, and the fundamental issues of measurement and payment. For the preparation of Works Bidding Documents the key documents requiring attention are:

Instructions to Bidders (ITB) and the Bid Data Sheet (BDS): The ITB is generally a standard document, slightly varying for the different clients. For a LVR project the client should include an additional item that will draw the attention of the bidder to the low volume road approach and any requirements for complementary interventions. The BDS is linked to the ITB and provides specific project information.

Standard Technical Specifications: These will define the scope of the technical requirements of the contract, including the type and quality of materials and equipment, the standards of workmanship. The Standard Technical Specifications form a separate volume in the ERA 2011 series and these capture most of the proposed interventions mentioned in this low volume road manual. The ERA Standard Technical Specifications includes information on the format of Bill Items for the Bill of Quantities, on item coverage and the method of payment.

Particular Specifications: This is where any detailed technical requirements and specifications, and implementation mechanisms specific for the project should be clearly defined. The particular technical specification should also include any specifications and limitations on the freedom of choice for the contracting company related to the execution of works. Particular technical specifications add further detail to complement or replace those stated in the Standard Technical Specifications.

Bills of Quantities or Schedules of Rates: This should be linked by item number to the Standard Technical Specifications and to the Particular Specifications; and is where the schedule of activities and estimated quantities are set out for the bidder to price.

Drawings: Some standard detailed drawings may be applied directly for low volume roads works (eg cross-sections, standard culvert design and signage). Supplementary drawings, linked with the Particular Specifications, may also be required where new, innovative or special approaches are included. Where trail bridges are included within the contract, as a complementary intervention, a separate volume of drawings is provided.

Conditions of Contract: This includes standard provisions for execution of the contract and unless amended in the Conditions of Particular Application, these will apply. It is anticipated for Major and Intermediate works projects that amendments may be required to reflect the desired approach for low volume road works. The simplified Conditions of contract with the standard Bidding Documents for Minor and Micro works should not need amending.

Conditions of Particular Application: This is where any Provisions in the General Conditions of Contract may be amended, as required, to make them more appropriate to the requirements of the low volume road approach, including complementary interventions.

In promoting small and medium scale enterprises; emergent contractors; employment intensive or labour-based works; and utilisation of intermediate equipment options, due consideration should be given to the clauses referring to Performance Security, Performance Program, Insurances, Cash Flow, Plant, Equipment & Workmanship, Payments, Retention and Advances, Price Adjustment and currency restrictions. There will be cases where the general conditions of contract may prevent, or work against, the small scale industry and these should be adjusted accordingly to promote competition and fairness to the emergent industry.

Due consideration should also be given to strengthening clauses aimed at promoting sub-contracting/ assignment; local employment and conditions (particularly for women); rights and insurances; and for strengthening complementary interventions.

User Guide's: These documents will provide detailed guidelines to the design consultant on the preparation of the Works Bidding documents.

Works Contract Evaluation: Recognition that the context of the works is using low volume road approaches must be included within the evaluation of bid process. The aim should be to ensure that the bidder confirms an understanding of the Client's perception for implementation. If complementary intervention requirements are built into the prospective works, the evaluation should also ensure that the complementary interventions are fully understood.

3.2 Supervision services

In addition to adequately defining the scope and understanding of the project and its approach for the works bid, it is essential that the same level of understanding is reflected in the Request for Proposals (RFP) for the supervising consultant. The RFP should specifically include appropriate inputs of key personnel with the requisite skills to meet the requirements of the low volume roads project approach. The supervising consultant should be fully familiar with the techniques and approaches to be employed on the works, including any complementary interventions.

The RFP should include:

- Clear definition of the role of the supervisor in the context of the project. If small scale or emergent contractors are employed, the client may require the consultant to act both as supervisor and mentor or to provide training, for example to client or authority staff;
- Clearly defined and appropriate inputs for key personnel with requisite experience on low volume road implementation;
- Requisite skills to cater for socio-environmental supervision and oversight of any complementary interventions;
- Reference to this Manual and supporting documents.