

**Volume 1  
Planning &  
Initial Design**

# Small Structures for Rural Roads

**A Practical Planning, Design,  
Construction & Maintenance Guide**

Paul Larcher, Robert Petts & Robin Spence  
English Version, May 2010



**global Transport  
Knowledge Partnership**

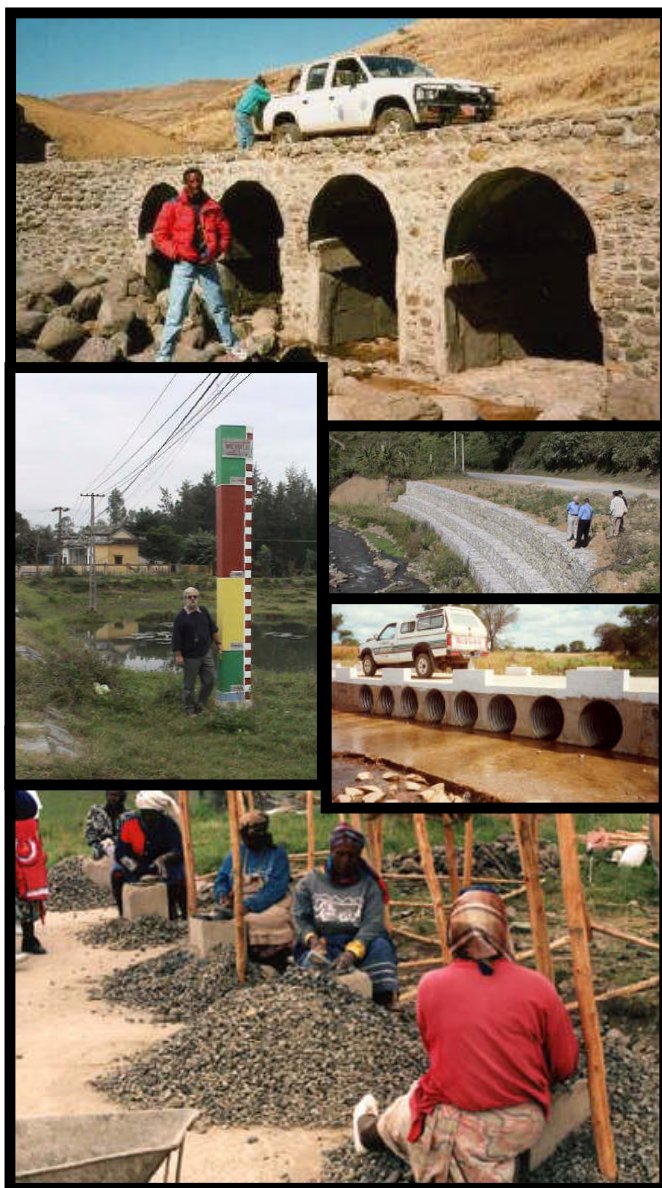
*committed to sustainable transport*





**global Transport  
Knowledge Partnership**

# **Small Structures for Rural Roads: A Practical Planning, Design, Construction & Maintenance Guide**



## **Volume 1 Planning & Initial Design**

**Compiled with  
contributions from the  
following organisations**



**SEACAP  
AFCAP**



***Paul Larcher, Robert Petts & Robin Spence  
English Version  
May 2010***

# **Small Structures for Rural Roads**

## **A Practical Planning, Design, Construction & Maintenance Guide**

<b>Volume 1</b>	<b>Planning &amp; Initial Design</b>
<b>Volume 2</b>	<b>Detailed Design, Construction &amp; Maintenance</b>
<b>Volume 3</b>	<b>Design Drawings and Bills of Quantities</b>
<b>Volume 4</b>	<b>Design Drawings (A3)</b>

The chart on Volume 1, Page 6 will assist the reader to navigate this document.

### Acknowledgements

The initial funding for the research and drafting of this guideline was provided by DFID (Department for International Development) through their Knowledge and Research (KaR) programme. The guideline has benefited from constructive advice and guidance from a large number of different people, too numerous to mention, for which the authors are very grateful. The following people have contributed in detail to the work; Andreas Beusch, Michael Broadbent, Able Chiteshe, Jasper Cook, Simon Done, Robert Geddes, Colin Gourley, Kingstone Gongera, Heng Kackada, Tesfaye Kunbi, Peter O'Neill, Kamal Pande, David Salter, Dave Stiedl and Julie Turner. The diagrams have been drawn by Patricia Petts. The authors are grateful to Simon Done, John Howe, Intech Associates and TRL for contributing a number of photographs for the guideline. All contributions are gratefully acknowledged. The authors are, of course, solely responsible for the opinions in this guideline.

Edition 1 May 2010

© Paul Larcher et al., 2010

Larcher P., Petts R. and Spence R. (2010)  
*Small Structures for Rural Roads; A Practical Planning, Design, Construction & Maintenance Guide (SSRRG)*

The original draft document (2005) was an output from a project funded by the UK Department for International Development (DFID) for the benefit of low-income countries. This current edition (2010) was updated and edited by TRL Ltd in association with Intech Associates, OtB Engineering (International) Ltd and KACE (Cambodia) through the DFID-South East Asia Community Access Programme (SEACAP). The document has been reviewed and finalised by the Global Transport Knowledge Partnership (gTKP) under management of the International Road Federation (IRF) with contributions from the World Bank, Asian Development Bank and the Africa Community Access Programme (AFCAP).

The views expressed are not necessarily those of DFID, WB, ADB or IRF.

Any part of this publication, including the illustrations (except items taken from other publications where the authors do not hold copyright) may be copied, reproduced or adapted to meet local needs without permission from the authors, provided the parts are distributed free, or at cost and not for commercial ends, and the source is fully acknowledged as given above.

The aim of this document is to provide guidance to planners, designers and practitioners of rural roads in developing and transition countries. It is based on proven techniques and experience and should be the basis of introduction of low cost but durable construction practices in environments experiencing severe resource restrictions. It is intended that rural road practitioners and professionals will be able to utilise and adapt the knowledge in this document to introduce more appropriate, affordable and sustainable techniques, standards and specifications into everyday practice, academic curricula and training, and contribute to rural poverty reduction.

This document is web-posted by gTKP ( [www.gtkp.com](http://www.gtkp.com) ) to be available to practitioners free of charge. Hard copies may be obtained on application to [info@gtkp.com](mailto:info@gtkp.com) .

It is intended that this Guideline should be a dynamic document with regular updates to accommodate new knowledge and experience. Users are actively encouraged to comment on and contribute to the ongoing development of this Guideline. Please send your comments or contributions for future editions to:

Robert Petts, Theme Champion, Rural Transport, gTKP [rob.petts@gtkp.com](mailto:rob.petts@gtkp.com)

## Contents

### Volume 1 Planning & Initial Design

<i>Acknowledgements</i>	iii
<i>Contents</i>	iv
<i>Abbreviations &amp; Glossary</i>	v
1. Introduction	1
2. Project Planning	8
3. Design Criteria	15
4. Structural Options	23
5. Site Selection and Appraisal	38
6. Watercourse Characteristics	50
7. Materials	59
Stone and stone masonry	59
Brick and block masonry	73
Timber and organic materials	79
Plain and reinforced concrete	89

### Volume 2 Detailed Design Construction & Maintenance

8. Structural Design	101
Scour	102
Foundations	106
Structural slabs	108
Cut off walls	111
Pipes	112
Headwalls and wingwalls	125
Apron	129
Approach ramps	130
Downstream protection	132
Arches	138
Bridge design	141
Other design issues	154
9. Construction	155
10. Maintenance	175
References	180

Volume 3 Design Drawings and Bills of Quantities

Volume 4 Design Drawings (A3)

## Abbreviations & Glossary

The list below contains the abbreviations and engineering words along with their meanings as they have been used in the guideline. Words in italics are also listed in the glossary.

Abutment	The support for each end of a bridge deck that also retains the material forming the approach embankments.
Aggregate	Stone, sand, gravel or other inert material forming the major constituent of concrete. Fine aggregate is less than about 5mm in diameter, coarse aggregate is greater than about 5mm in diameter.
Approach embankments	The earthworks that carry a road to a bridge, culvert or other structure
Apron	The flat area at the inlet and outlet of a culvert or the area of the watercourse bed which is protected downstream of a structure.
Arch bridge	A structure consisting of a curved beam spanning between the abutments, which may support a road over a watercourse, rail line or other road.
Barrel	1. The main part of an arch which supports fill material or masonry superstructure. 2. The pipe or box part of a culvert which carries the flow of water.
Bearing	A connection between a bridge deck and abutment or pier that allows differential movement between the deck and supports.
Bill of Quantities	A list of all construction activities (materials, labour, supervision, transport etc) and other measures and requirements necessary to build a structure, which enables a total cost of the structure to be calculated through the application of quantities and unit rates.
Bio-engineering	The use of vegetation in engineering design to protect natural terrain and man-made structures from the problems associated with soil erosion.
Block(s)	Blocks are uniformly sized masonry units, normally made from aggregates and cement and designed to satisfy standards requiring a minimum crushing strength.
BoQ	<i>See Bill of Quantities.</i>
Brick(s)	A rectangular masonry unit made of baked clay or sand/cement, for example with dimensions 225 x 112.5 x 75mm.
Bridge	A structure with a span of 3 metres or more which permits the crossing of a watercourse (or another road or railway etc.) consisting of abutments and a deck. Bridges may also have wingwalls, approach embankments and pier(s). [This guideline considers bridges with spans up to 10m].
Camber	A slope across the width of the road to ensure water drains off the carriageway.
Carriageway	The part of the road that is normally driven over by vehicles.
Catchment area	The area drained by a watercourse.
Causeway	Similar to a vented drift. Causeways tend to be longer than vented drifts and have a larger number of openings.
Cement	A grey powdered substance, usually derived from processed limestone, which when mixed with water sets and hardens to

## Small Structures for Rural Roads

	form the binder in concrete.
Cofferdam	A temporary dam to exclude water from a submerged area allowing construction or maintenance work to be carried out.
Concrete	A manmade material which has similar properties to stone and is made from cement, aggregates and water.
Contours	Lines on a map which join points of the same altitude.
Cover	1. The thickness of fill material between the top of a culvert pipe or arch and the road surface. 2. The thickness of concrete between its outside face and a reinforcement bar.
Culvert	A structure which allows water to flow under a road. Culverts are usually up to 1.2m in diameter and may be round, square or arched.
Dead load	The weight of a structure including any items fixed to it.
Debris rack / grill	An open structure built upstream of a culvert, drift or bridge to collect debris (e.g. driftwood) and thereby prevent clogging of the road structure.
Deck	A part of a bridge which spans between abutments or piers and is driven on by traffic.
Design flood	The discharge of water used to calculate the size of a bridge or culvert opening. The design flood is normally based on an estimated probability of occurrence at a certain return period.
dia	diameter
Discharge	The amount of water which flows past a point in a watercourse in a given time.
Downstream protection	Engineering work carried out in a watercourse to prevent scour or erosion.
Dressed (stone)	Stone that has been shaped into rectangular blocks.
Drift	A simple structure, constructed from local or imported materials, which provides vehicles with a firm surface to drive through a watercourse.
Embankment	Compacted earth which supports a road above the normal ground level.
Falsework	Temporary boards or sheets and other materials used to support the <u>underside</u> of a concrete structure during hardening e.g. on the deck of a bridge. See <i>Formwork</i>
Ford	See <i>Drift</i>
Formwork	1. Temporary boards or sheets and other materials used to contain concrete and produce its final shape during hardening. 2. Temporary boards or sheets used to provide support and give arches their shape during construction. See <i>Falsework</i>
Foundation	The lowest part of a structure on which the rest of the structure is supported. Foundations are usually under the ground.
Gabion	Stone filled steel wire or mesh cage. Gabions can be used for retaining walls, abutments, downstream protection and drifts.
Headwall	A wall at each end of a culvert pipe used to retain the road formation.
High flood	The highest flood level that is known to have occurred in a watercourse.
IMT	Intermediate Means of Transport (e.g. bicycles, motorcycles, carts)
Invert	The floor of a culvert or channel.
Invert slab	See <i>drift</i> .

## Small Structures for Rural Roads

Irish bridge	See <i>drift</i> .
Kerb	A hard edge to a road that stands up above the level of the carriageway.
Large bore culvert	A culvert with a diameter of greater than 1 metre.
Live load	A temporary load on a structure e.g. pedestrian or vehicle.
Low level water crossing	Drift, splash, causeway, Irish bridge or (vented) ford.
m	metre
mm	millimetre
m <sup>3</sup> /s	cubic metres per second
Masonry	A generic term used to describe the following materials; <i>bricks, blocks, dressed stone, random stone, rubble</i> .
Mass concrete	Concrete without any reinforcing steel.
MFL	Maximum Flood Level.
Mortar	Mortars are composed of clean sand and a binding agent (such as cement) and are used to bond masonry units together.
N	Newton
N/A	Not Appropriate
Outfall	The point where a culvert or channel discharges water.
Overtopping	When water flows are greater than the capacity of a channel or culvert, water will flow onto surrounding ground, above the channel. Embankments may also be overtopped.
Parapet	The protective barrier, wall or railing at the edge of a bridge deck or other structure.
Permeability	The rate at which water (or other liquid) will flow through the soil.
Pier	A wide column or wall used to support long bridge decks.
Pile	A pole driven into the ground, used as a foundation. Piles can be made from timber, steel or concrete. (guidance on the use of piles is not covered in this guideline).
Piped drift	See <i>vented ford</i> .
Plasticiser	A plasticiser is an additive to the mortar used in small quantities to improve the workability of the mix or to achieve the same workability with less water, thus improving both strength and durability.
Plum	A large stone put into mass concrete to reduce the volume of cement required.
Pozzolan	A natural or man-made material which when mixed with water displays similar properties to cement.
Prestressed (concrete)	A method of increasing the strength of concrete using high strength steel bars, prestressed before the concrete sets (not covered in this guideline).
Post-tensioned (concrete)	A method of increasing the strength of concrete using high strength steel bars or cables, tensioned after the concrete sets (not covered in this guideline).
Random stone masonry	Masonry constructed from stones with minimal dressing.
Reinforcement (concrete)	Steel rods or mesh placed into concrete to increase it's strength.
Reno mattress	A long wide, flat <i>gabion</i> .
Retaining wall	A wall used to hold back soil.
Return period	The average time between two storms producing the same design flood.
Rip-rap	Stones, generally between 5kg and 100+kg, used to protect a

## Small Structures for Rural Roads

	watercourse from scour.
Road structure inventory	A list or database of all the structures on the road network, which allows planning of inspection and maintenance.
Rubble masonry	See <i>Random stone masonry</i> .
Running board	Boards which are fixed to the bridge deck in the direction of traffic flow, on which the vehicle wheels run. They provide protection to the floor planking from wear and tear from heavy vehicles.
Runoff	Water which flows over the ground as a result of rain.
Scour	The deepening and/or widening of a watercourse or channel due to erosion by flowing water.
Scupper	A vertical or horizontal hole through a bridge deck or parapet for the purpose of deck drainage.
Settlement	Small movements (downwards) of part or all of a structure due to compression of the ground below.
Shuttering	The part of formwork that is actually in touch with the concrete.
Soffit	The underside surface of a beam, deck slab or an arch shape e.g. in a culvert pipe.
Splash	See <i>ford</i> .
Springing	The ends of the curve of an arch.
Substructure	The foundations, abutments, piers and other parts of a bridge that support the deck and associated items (see <i>superstructure</i> ).
Superstructure	The deck, beams, parapets and other items associated with the deck of a bridge.
Surcharge	Material placed above and behind a <i>retaining wall</i> which has the effect of applying an additional horizontal load on the wall.
Topography	The characteristics of land in terms of elevation, slope and orientation.
Trial pit	A pit dug to determine the ground conditions at a proposed structure site.
Vented ford / drift	A low level structure built across a stream or river with openings to allow water to pass through. After heavy rain additional water may flow over the top of the structure temporarily submerging the roadway.
vpd	vehicles per day
Watercourse	A natural drainage channel in which water may or may not be flowing.
Watershed	An imaginary line along a ridge between two catchment areas, from which water flows away in both directions – the limit of a water catchment.
Watertable	The level at which the ground is fully saturated with water.
Waterway	An artificial (manmade) channel designed to carry water.
Weep holes	Small openings (often pipes) in the bottom of retaining walls and abutments to allow drainage of water from behind a structure, reducing the pressure on that structure.
Whole life cost	The total cost of a structure which includes design and construction costs, in addition to regular and periodic maintenance over a period of time (the life of the structure).
Wingwall	A retaining wall adjacent to a bridge abutment to support the embankment fill. Wingwalls may also be found adjacent to a culvert headwall.
x-section	Cross section