



Engineering Module 4

Low Volume Rural Road Construction Issues

DF 55: Dissemination of LVRR Knowledge and Experience



Summary

This module presents key issues relating to the construction of LVRR pavements and associated drainage. The need to comply with the design specifications is of a paramount importance not only in regard construction materials abut also in respect of construction plant and construction procedures. There is clear need to improve the quality control on rural road construction and this module highlights important issues to be considered .

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Points to Think About

Why are specifications important?

What is the cost of poor construction to rural communities ?

Why do we need good drainage?

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EM4.1 Specification Compliance

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Pavement Specifications

The construction of road pavements should be governed by adherence to the relevant contract specifications, which should be:

- Clear and understandable
- Appropriate to the local road environment
- Capable of being applied by local contractors
- Aimed at producing a technically sustainable road
- Cover all relevant technical and cost issues
- Compatible with overall Vietnamese regulations

Specifications

Contract specifications normally cover the complete range of activities required to complete the construction of a required road in a satisfactory manner, including:

- Site preparation
- Setting out and surveying
- **Pavement construction plant and procedures**
- **Construction materials**
- **Drainage**
- Structures

New Specifications

Seals

Sub-Base -
Base

| Reference | Specification |
|-----------|--|
| RRST 1-01 | Bituminous Emulsion – Surface Dressing Chip seal |
| RRST 1-02 | Bituminous Emulsion – Sand Seal |
| RRST 2-01 | Gravel Sub-Base/Base |
| RRST 2-02 | Lime Stabilised Sub-Base/Base |
| RRST 2-03 | Cement Stabilised Sub-Base/Base |
| RRST 2-04 | Emulsion Stabilised Sub-Base/Base |
| RRST 2-05 | Armoured Gravel Roadbase |
| RRST 2-06 | Sand Sub-Base |
| RRST 2-07 | Quarry-Run Sub-Base |
| RRST 2-08 | Graded Crushed Stone Sub-Base/Base |
| RRST 2-09 | Sand Bedding Layer |
| RRST 2-10 | Dry Bound Macadam Sub-Base/Base |

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New Specifications

Block
Paving

Concrete

Shoulders

| | |
|-----------|---|
| RRST 3-01 | Fired Clay Brick Pavement – Unmortared Joints |
| RRST 3-02 | Fired Clay Brick Pavement – Mortared Joints |
| RRST 3-03 | Cement Brick Pavement – Mortared Joints |
| RRST 3-04 | Mortared Dressed Stone |
| RRST 3-05 | Cobble Stone Paved Surface |
| RRST 4-01 | Bamboo Reinforced Concrete |
| RRST 4-02 | Steel Reinforced Concrete |
| RRST 4-03 | Non-Reinforced Concrete |
| RRST 5-01 | Gravel Shoulders |
| RRST 5-02 | Lime Stabilised Shoulders |
| RRST 5-03 | Cement Stabilised Shoulders |
| RRST 5-04 | Quarry-Run Shoulders |
| RRST 5-05 | Sealed Macadam Shoulders |

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Why Quality Assurance ?

Roads must be constructed to comply with specifications.

Badly constructed roads will fail early and not perform their task

This WASTES GOVERNMENT AND LOCAL COMMUNITY MONEY

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Construction Quality Control is Therefore Essential



Poor site procedures eliminated.

Design compliance enforced.



As-built inspections specified

Key Areas

1. **Materials approvals**
2. **Pavement layer approvals**
3. **In situ testing**
4. **As-completed Quality Assessment**



Details in a following presentation

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Construction Materials Specifications

The ability of the material to perform its function in the road is normally assessed by its compliance, or non-compliance, with construction material specifications.

These should control the impacts of excavation, transportation, processing, compaction and placing, and the in-service impacts of both the traffic and environment depending on the nature and position of the materials in the pavement structure.

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Construction Materials Specifications

It is not realistic to attempt to force contractors to meet inappropriate or unobtainable standards.

For overall cost-effectiveness and minimization of environmental impact, LVRR specifications should where possible take into account the nature of locally available materials.

Hence the use of flexible material specifications that acknowledge local material variations is recommended.

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Construction Materials Specifications

It must be recognised that the consequence of using more focussed specifications may be a greater need to ensure that the materials actually comply the requirements and that the material approval for use needs to be accompanied by clear guidelines laying out the limits within which the approval is valid.

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Construction Plant and Procedures

Introduction to the Construction Guidelines

The RRSST Construction Guidelines synthesize the knowledge and experience developed under the RRSR; including the RRSST and RRGAP, as well as from other sources.

The main body of the document then comprises a series of technical chapters relating directly to specific RRSST pavement options and their specifications, grouped as follows:

- Surface seals
- Stabilised bases and sub-bases
- Non stabilised bases and sub-bases
- Block pavement options
- Cement Concrete pavements

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Construction Plant and Procedures

Key Issues

This section of Module E4 summarises some of the key issues with respect to the plant and procedures to be used in the construction of the RRST Pavement options. The relevant references in the RRTS Guidelines are as follows:

| | |
|------------------------------------|----------------------|
| Bituminous Emulsion Seals | Section 4 and App A1 |
| Stabilised Bases and Sub-bases | Section 5 and App A2 |
| Non Stabilised Bases and Sub-bases | Section 6 and App A3 |
| Block Pavements | Section 7 and App A4 |
| Concrete Pavements | Section 8 and App A5 |

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Construction Plant and Procedures

Bituminous Emulsion Stone Chip Seal

Description

SBSD: Spreading of stone chips

Surface Dressing consists of supply and application of a seal of bituminous binder material over the previously prepared road base. The seal is immediately covered with single sized stone aggregate chippings. The chippings completely cover the seal and are lightly rolled into the seal to form an interlocking mosaic. The surface dressing acts as a waterproof seal and running surface.

Key Issues: Material Selection

Bitumen Emulsion
Aggregate

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Construction Plant and Procedures



Key Issues: Construction and Supervision



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Construction Plant and Procedures

Stabilised Bases and Sub-bases

General

When the only economically available natural materials contain a considerable quantity of high plasticity fine material and/or a relatively high proportion of weak particles, it may become impractical or even impossible to produce a satisfactory base or sub-base from the untreated material. In such cases locally available materials may be effectively improved by treatment with an additive such as cement, lime, bitumen or a proprietary chemical.

The RRST procedures described in this document are concerned only with the in situ mixing of the following stabilisers, using locally available agricultural equipment.

Hydrated Lime: Specification RRST 202

Portland Cement: Specification RRST 203

Bitumen Emulsion: Specification RRST 204



Construction Plant and Procedures

Stabilisation is carried out primarily to increase strength and bearing capacity, although other benefits can be achieved such as:

To control volume or strength variability when moisture content changes.

To increase the resistance to erosion, weathering or traffic usage.

To reduce the permeability of the stabilised soil.

Stabiliser Selection

Selection of the appropriate stabiliser is a key initial issue and the principal factor to be considered when selecting the most suitable method of treatment is the type and geotechnical nature of the material to be treated.

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Construction Plant and Procedures

| Type of Stabilisation | Soil Properties | | | | | |
|-----------------------|--|--------------|---------|---|---------|---------|
| | More than 25% passing the 0.075 mm sieve | | | Less than 25% passing the 0.075mm sieve | | |
| | PI < 10 | 10 < PI < 20 | PI > 20 | PI < 6 PP < 60 | PI < 10 | PI > 10 |
| Cement | S | S | M | S | S | S |
| Lime | M | S | S | X | M | S |
| Bitumen/Emulsion | M | M | X | S | S | X |

Key

PI: Plasticity Index

PP: Plasticity Product (PI x % passing 0.075mm)

S: Suitable

M Marginally Effective

X: Not Suitable

Construction Plant and Procedures

Special Testing Procedures

- Laboratory strength testing on the proposed materials during the design phase of any rural road works must indicate the percentages of stabiliser required for effective modification of the natural materials. This testing must be repeated on the actually identified project material sources as soon as they are confirmed at contract stage.
- *Construction Plant*
- The following essential plant should be available and in good proven working order on site:
 - Single axle tractor rotovator or 2-axle tractor driven rotovator with blades capable of mixing to a loose material depth of 20 cm or more.
 - A minimum 3 tonne vibrating roller;

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Construction Plant and Procedures

- Lime Stabilised Sub-Base/Base; Specification RRST 202
- *Description*
- *Key Issues: Materials*
- Lime - Natural Materials - Stabilised Materials
- *Key Issues: Construction and Supervision*
- *Key Issues: Site Testing*
- Cement Stabilised Sub-Base/Base; Specification RRST 2.03

Note: Referring the guidelines in detail.

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Construction Plant and Procedures

▪ Non Stabilised Bases and Sub-bases

Non Stabilisation Options

Armoured Gravel Road-Base; Specification RRST 205

Description, Materials, Construction and Supervision, Site Testing

Sand for Sub-Base; Specification RRST 206

Quarry Run for Sub-Base; Specification RRST 207

Graded Crushed Stone for Sub-Base; Specification RRST 2.08

Dry Bound Macadam Base/Sub-Base; Specification RRST 2.10

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Construction Plant and Procedures

Block pavement options

Fired Clay Brick Pavement; Specifications RRST 301 and RRST 302

Description, Materials, Construction and Supervision, Site Testing

Concrete Brick Pavement; Specifications RRST 303

Cobble Stone Pavement; Specifications RRST 304

Mortared Dressed Stone Pavement; Specifications RRST 305

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Construction Plant and Procedures

- **Cement Concrete Pavements**
- **General Descriptions**
- **Materials, Construction and Supervision,**
- **Bamboo Reinforced Pavement; Specifications RRST 401**
Description, Materials, Construction and Supervision, Site Testing
- **Steel Reinforced Pavement; Specifications RRST 402**
- **Non-Reinforced Pavement; Specifications RRST 4.03**

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EM4.3 Pavement Drainage

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Importance of Drainage

Pavement drainage is frequently emphasised in design manuals as being of the utmost importance, however, there is a significant problem in applying drainage principles in construction and maintenance practice .



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Commonly observed problems

- Inappropriate “boxed-in” pavement design
- Missing and poorly maintained side drainage
- Insufficient or badly sited cross drainage (culverts)
- Lack of maintained road shape (cross-fall) on unsealed roads
- Build-up of vegetation and debris on shoulders preventing adequate run-off

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Main Functions

A good road drainage system, which is properly maintained, is vital to the successful operation of a road. It must:

Convey rainwater from the surface of the carriageway to outfalls

Control the level of the water table in the subgrade
Intercept surface water flowing towards the road

Convey water across the line of the road in a controlled fashion.

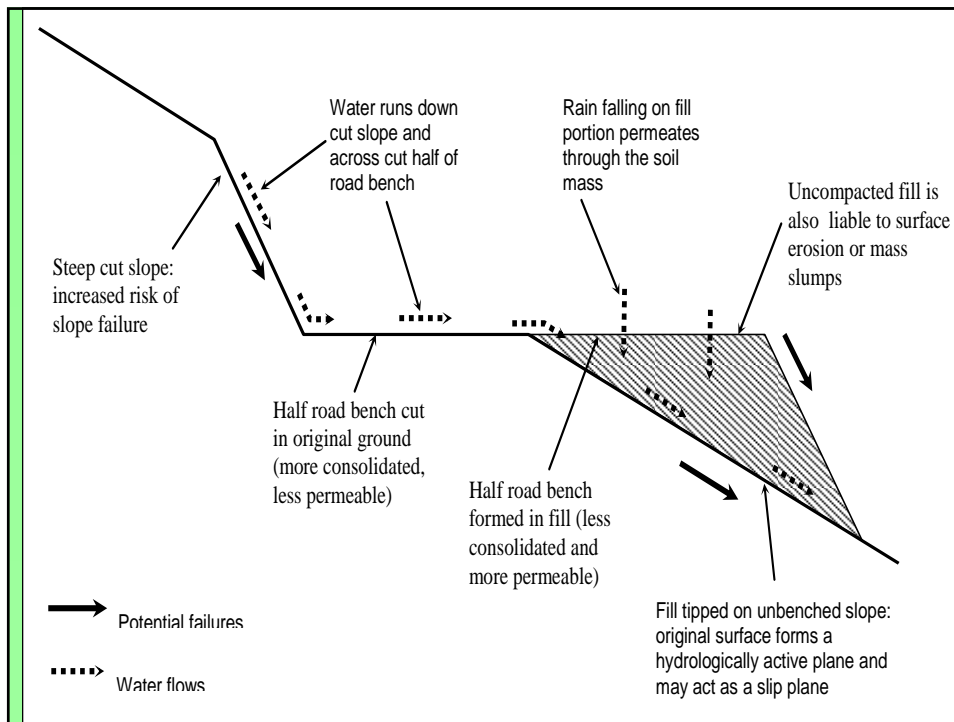
The first three functions are performed by side drains and the fourth by culverts, drifts and bridges

Earthworks Drainage

There are also significant drainage issues related to the maintenance of earthwork stability.

This is of particular importance in hilly or mountainous terrain where poor drainage can have severe consequences on the provision of all-year access, with significant consequences for the rural communities for which the LVRRs are designed to serve.

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Carriageway Drainage

If water is allowed to enter the structure of the road, the pavement will be weakened. Water can enter the road as a result of rain penetrating the surface or as a result of the infiltration of ground water.

The road surface must be constructed with a camber so that it sheds rain water quickly and the formation of the road must be raised above the level of the local water table to prevent it being soaked by ground water

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Boxed-in Cross sections

The 'trench' type (or boxed-in) cross-sections in which the pavement layers are confined between continuous impervious shoulders should not be used.

If this type of design is unavoidable, drainage grips of graded granular free draining material, 300mm wide and extending from under the base and for the full depth of the sub-base layer under the shoulder are recommended every 5 metres.

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Crossfalls

On sealed roads provided crossfalls (4%) are adhered to and the surfacing and shoulders are properly maintained, rainwater falling on the road will be shed steadily over the shoulders.

Unsealed gravel surfaces require a greater crossfall of 6 %

When permeable roadbase materials are used, particular attention must be given to the drainage of this layer. Ideally, the roadbase and sub-base should extend right across the shoulders to the drainage ditches, this has however significant cost implications



Poor Crossfall and Road shape – Collection of Water and Pavement Deterioration



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External Drainage

Both in the design and in maintenance of drainage, it is important to interfere as little as possible with the natural flow of water.

Culverts on natural water-courses should follow the existing alignment as closely as practicable. Flows in drains and culverts should also be kept to a minimum by the use of frequent turnouts where side drains cannot be discharged to existing watercourses. In sidelong ground, where discharge from the side drain on the high side passes to the low side, it is best to use frequent small culverts rather than occasional large ones.

External Drainage

Suitable guidance for LVRR external drainage is given in the following documents:

- TRL Ltd, 1997, Principles of Low Cost Road Engineering in Mountainous Regions
- TRL Ltd, 2000, Overseas Road Note 9, A Design Manual for Small Bridges.
- Vietnam



Poor Drainage
Leads to Road
Failure

Missing Culvert?
No Side Drains ?
Earthworks too low ?



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Adequate Side
Drainage
(Some routine
maintenance
required)



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Scour Protection

A side ditch will only perform as designed if the design cross-section is maintained, i.e. excessive scour must be prevented.

In practice, due to local inconsistencies in roughness and surface level, no side drain in any but the hardest of materials will be immune from scour. Thus, for long lengths of side ditch at gradients in excess of 4-5%, scour checks should be considered.

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Scour Protection

| Ditch Material | Maximum Allowable velocity(m/s) |
|---------------------------------------|---------------------------------|
| Sand, loam, fine gravel, volcanic ash | 0.6* |
| Stiff clay | 1.1* |
| Coarse gravel | 1.5 |
| Conglomerate, hard shale, soft rock. | 2.0 |
| Hard rock | 3.0 |
| Masonry | 3.0 |
| Concrete | 3.0 |

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