Low Volume Rural Road Research in Vietnam on Unsealed and Sealed Roads

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David Salter; SEACAP

The Ministry of Transport in Vietnam recognised an unsustainable reliance by donor programmes on unsealed gravel roads to solve the rural access problems in Vietnam.
The Rural Road Surfacing Research (RRSR) programme – 2 approaches:

An assessment of how unsealed gravel roads were actually performing—the Rural Road Gravel Assessment Programme (RRGAP)

Research into sustainable alternatives to unsealed gravel—the Rural Road Surfacing Trials (RRST)

Key RRSR Aim
SUSTAINABLE RURAL ROADS
Vietnam contains some particularly challenging road environments for unpaved roads.

- Erosive high rainfall
- Poor maintenance
- Variable terrain
- Coastal floods
Rainfall Hue 2006-08

2007-2008
3 storms @ 300-350mm/24 hrs

Traffic (Vietnam)

<table>
<thead>
<tr>
<th></th>
<th>Motor Vehicles</th>
<th>Motor-Cycles</th>
<th>Cycles</th>
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</thead>
<tbody>
<tr>
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<tr>
<td></td>
<td>31</td>
<td>540</td>
<td>305</td>
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<td></td>
<td>67</td>
<td>572</td>
<td>776</td>
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</table>
In Vietnam the SEACAP work was carried out as part of the Ministry of Transport Rural Road Surfacing Research (RRSR) programme – supported by DfID and World Bank Rural Transport Programmes 2 and 3.
Gravel Loss - (95% Level)

20 mm/yr: Limit of sustainability

Gravel Loss Comparison

Unsealed macadam type surface (Coarse stone)
Northern Hills

Unsealed Clayey Lateritic Gravel:
Low lying Mekong Delta

Unsealed Gravel Roads
Control Section

As Built

After 6 Months

Cross-Section D (4m)

Height Above TBM (mm)

RRST I & II

SEACAP 19 Inception Progress – Presentation 3
### Wide Range of Pavement Material Options Trialled

<table>
<thead>
<tr>
<th>Emulsion seals</th>
<th>Clay bricks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitumen seals</td>
<td>Concrete bricks</td>
</tr>
<tr>
<td>Unsealed gravel</td>
<td>Cobble stones</td>
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<tr>
<td>Armoured gravel</td>
<td>Quarry- run</td>
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<tr>
<td>Waterbound macadam</td>
<td>Bamboo RC</td>
</tr>
<tr>
<td>Drybound macadam</td>
<td>Steel RC</td>
</tr>
<tr>
<td>Graded crushed stone</td>
<td>Non-reinforced</td>
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<tr>
<td></td>
<td>Concrete</td>
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</tbody>
</table>

### Trial Selection and Design Principles

- Engineering based
- Appropriate to the road environments.
- Local construction materials
- Maintenance burden in line with local resources
**SEACAP**

**Trial Options**

- **H6**
  - 30mm
  - 70mm

- **H7 (H11-N)**
  - 150mm
  - 200mm

- **H8**
  - 100mm
  - 100mm

- **H9**
  - 70mm
  - 50mm

- **H10**
  - 50mm
  - 100mm

**HUE TRIAL PAVEMENT DESIGNS**

- **H1-C**
  - 80mm
  - 100mm

- **H2-C**
  - 100mm
  - 100mm

**Trial Layouts**

- **HUE Trial Section Layout**
  - Bitumen sand seal
  - Penetration Macadam
  - Stone Macadam
  - Sand
  - Concrete
  - Concrete bricks
  - Natural gravel/laterite
  - Mortared dressed stone

**Hue RRST-1**
Road Research Delivery

- Trial Construction
- Monitoring & Analysis
- Practical dissemination
- Road Standards & Specifications

Monitoring

- Condition monitoring essential
- Standard procedures (eg ORN 18)
Monitoring Summary
Roads divided into 4 categories

<table>
<thead>
<tr>
<th>Trial Type</th>
<th>Sections</th>
<th>Length (km)</th>
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<tbody>
<tr>
<td>Block</td>
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<tr>
<td>Concrete</td>
<td>24</td>
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<td>Sealed Flexible</td>
<td>56</td>
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<tr>
<td>Unsealed</td>
<td>16</td>
<td>1.670</td>
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The Road Condition Deterioration Index (RCDI)

A total deterioration index: the condition of the key factors as percentage of total deterioration (ie all visual numeric codes at their maximum defect values).
Made up of individual factor indices (CDIs)
## Joint Seals: Concrete Slabs

<table>
<thead>
<tr>
<th>Age (Months)</th>
<th>CDI%</th>
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<tr>
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</tr>
<tr>
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<td>36</td>
<td>60</td>
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<tr>
<td>48</td>
<td>80</td>
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</table>

### CDI% vs. Age (Months)

- **"D2"**
- D3
- H2
- TG2
- TG3
- TG9

### Table:

<table>
<thead>
<tr>
<th>Chain</th>
<th>Stone blocks</th>
<th>Matrix</th>
<th>Defects</th>
<th>Surface condition</th>
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<tr>
<td>100</td>
<td>11</td>
<td>1</td>
<td>1</td>
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</tbody>
</table>

### Chain Block:

- Left Hand
  - Carriageway
  - Shoulder
- Right Hand
  - Carriageway
  - Shoulder

### Defects:

- Stone blocks
- Matrix
- Depressions
- Rutting
- Potholes
- Shape
- Edge
- Cracks
- Erosion
- Run-off
- Drain

### Surface Condition:

- Chain Block
- Stone blocks
- Matrix
- Depressions
- Rutting
- Potholes
- Shape
- Edge
- Cracks
- Erosion
- Run-off
- Drain

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**SEACAP 19 Inception Progress – Presentation 3**
### Surface Cracks Sealed Flexible Options

- Cement Stab Base /S-base
- Cement Stab Base/Emulsion S-Base
- Emulsion Stab Base/S-Base
- Pen Mac/WBM
- Deterioration Extent
- Deterioration severity

### MAINTENANCE COST AND ROAD CONDITION INDEX

<table>
<thead>
<tr>
<th>Trial sections</th>
<th>Age month</th>
<th>Repair cost of 1km of road up to 8/2008 (USD)</th>
<th>Road Damage Condition Index (RDCI)</th>
<th>Damage Extend Index (DEI)</th>
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<tr>
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<td>491</td>
<td>3 86</td>
<td>5</td>
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</table>
Block Pavements

- The single sand seals have performed poorly.
- The minimum strength requirement of 20-25MPa for manufactured engineering quality bricks is important.

Mortared jointed options are probably more appropriate than sand joint options.

Stone options: robust but rough
Concrete

The results of the trials of bamboo reinforced concrete in Vietnam (together with results obtained in Cambodia) show conclusively that bamboo reinforcement in pavement slabs has no obvious advantage over well-constructed non-reinforced concrete.

Two principal causes for poor performance stand out:
Poor quality concrete and poor support for the concrete slabs (sub-base or eroded shoulders).
Flexible Pavements

Emulsion DBST over DBM is performing better than hot bitumen DBST over WBM.

Poor construction - major issue.

Unsealed Gravel

The majority of gravel control sites performed poorly - however there are clearly areas where unsealed gravel surfaces are a sustainable LVRR option provided they are constructed correctly and MAINTAINED.

Unsealed WBM is not a realistic option because of loss of cohesive fines and surface loosening.
The use of natural gravel as a universal rural road surface is unsustainable in the majority of the situations in Vietnam.

Other options are available that can be competitive in WLC terms.

The combination of sustainable gravel use and other trialled options within an Environmentally Optimised Design (EOD) process offers a potentially very useful way forward.
Summary

1. Construct Trials
2. Assess specifications & construction procedures
3. Collect data on as-built trial condition
4. Use information for assessing option suitability
5. Assess trial costs under full-scale conditions
6. Monitor Trial performance with associated maintenance and WL costs
7. Fully disseminate and apply to all provinces
Thank You