LOW COST ROAD SURFACING (LCS) PROJECT

LCS WORKING PAPER No 22

Sustainable Access Surfacing Techniques suitable for construction by Local Enterprises

by

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TABLE OF CONTENTS

FOREWORD

THE LOW COST ROAD SURFACING INITIATIVE

The Low Cost Road Surfacing (LCS) initiative aims to provide documentation and international guidelines on the provision and maintenance of low cost road surfaces and basic access for rural communities in economically emerging and developing countries (EDCs). It is based on a research project funded principally by the British Department For International Development (DFID) under its Knowledge and Research (KaR) programme. The initiative is led by UK-based specialist consultants Intech Associates. Collaboration has been established with a number of organisations with interests or experience in the sector, including TRL Ltd, CSIR, ILO/ASIST Africa and Asia-Pacific, the ILO-SIDA funded Upstream Project and Ministry of Rural Development Cambodia, WSP International, Ministry of Transport Vietnam, Greater Mekong Sub-region Academic Research Network, The Institute of Technology of Cambodia (ITC), Chieng Mai University Thailand, the Committee C20 (Appropriate Development) and Committee TC2.5 (Rural Roads and Accessibility) of PIARC (World Road Association) and the International Focus Group (IFG) for Rural Road Engineering.

The LCS programme is concerned with supporting sustainable improvements in low cost, road surfacing and basic access to support poverty reduction initiatives in rural communities. This implies the effective use of local resources, particularly human resources, locally available and alternative materials, and readily available and low cost intermediate equipment wherever possible. In the situation of scarce financial resources, it also requires the application of affordable and appropriate standards and adoption of techniques suitable for use by the indigenous private sector (particularly small domestic construction enterprises) and local communities. The application of good management practices coupled with adequate technical inputs are necessary to achieve appropriate and sustainable access.

It is intended that dissemination of the guidelines will be through electronic media as well as more traditional publication routes.

RURAL TRANSPORT PROJECT 2 (RT2), VIETNAM

DFID and World Bank have been funding the Ministry of Transport (MoT) Second Rural Transport Project (RT2) in Vietnam that is providing basic access roads for communities in 40 provinces of Vietnam (2001 – 2005). Gravel has been the surface usually provided for the project roads. Following concerns that gravel surfacing is not the optimal solution for rural roads in all circumstances in Vietnam, and at the request of the Government of Vietnam MoT, DFID commissioned studies of alternative surfacings for Rural (District and Commune) Roads in Vietnam under the support for RT2. Intech Associates and TRL Ltd were appointed to carry out the preparation and management of the Rural Road Surfacing Trials (RRST) identified as required to develop national guidelines.

Intech-TRL have also carried out Rural Road Gravel Performance studies in Vietnam to develop guidelines on the use and limitations of gravel surfacing.

SOUTH EAST ASIA COMMUNITY ACCESS PROGRAMME (SEACAP)

A substantial programme of DFID funded research projects is now underway in Cambodia, Laos and Vietnam under the South East Asia Community Access Programme (SEACAP). These research and dissemination initiatives follow on from the previous Infrastructure and Urban Development (IUD) Engineering Knowledge and Research (EngKaR) programme. The SEACAP programme currently includes some 20 projects. SEACAP builds upon the successful DFID collaborative research projects already completed in Cambodia and Vietnam on identifying ways to improve sustainable access to rural communities to facilitate access to health, education, trade, social facilities and services, thereby creating opportunity for pro-poor growth and escape from poverty. Dissemination of the LCS guidelines will be facilitated by SEACAP.

INTERNATIONAL FOCUS GROUP

TRL have been carrying out a number of research projects on low volume sealed and unsealed roads for DFID and other donors. Intech Associates have been carrying out research on low cost surfacing and rural road maintenance with a number of partners. As part of these projects, an International Focus Group (IFG) has been established. The intended function of the IFG was to thoroughly examine technical, economic and social issues arising from the project work. The group would also provide a focus to improve opportunities for dissemination of project results. The IFG is continuing to develop as an international forum and will comprise technical experts and engineers from a number of African, Asian, American and other countries as well as other international experts. Participation in the IFG provides opportunities to:

- *build regional and international partnerships*
- *exchange ideas, experiences, information and data*
- *strengthen local knowledge with new information*
- *build on existing local research*
- *promote wider acceptance and mainstreaming of the Rural Road Engineering knowledge*

Four projects listed below, were the foundation of the IFG. Projects 1, 2 and 4 were part of the DFID's Knowledge and Research programme, whilst Project 3, was a collaborative research project involving a number of different donors:-

Project 1: Reducing Whole Life Costs: Environmentally Optimised Design

Project 2: Minimising the Cost of Sustainable Basic Rural Road Access

Project 3: Engineering Standards for Labour-based Roads

Project 4: Low Cost Road Surfacing

The IFG has supported the exchange of knowledge and dissemination on rural road surfacing through its membership in the development of the LCS research work programme.

Further information may be obtained from:- www.ifgworld.org

TRANSPORT LINKS

DFID and previous UK government administrations have a long history in funding, promoting and disseminating transport research for developing countries and countries in transition. Through the Knowledge and Research (KaR) programme, DFID has supported a range of research projects addressing technical, economic, management and policy issues in transport development.

Many of the research outputs may be downloaded from: www.transport-links.org

TRANSPORT KNOWLEDGE PARTNERSHIP (TKP)

The Transport Knowledge Partnership (TKP) is an innovative approach to making more effective use of available knowledge, and encouraging greater participation from developing and transition countries in the management and application of knowledge. It is innovative in that it seeks to work with and through existing initiatives that have been established by its partners; in some cases supporting on-going ideas and programmes and, in others, promoting new directions of activity. It is a partnership in that it seeks to bring together all transport stakeholders and give them equal voice in how TKP develops as a concept.

Further information may be obtained from:- www.gtkp.org

PIARC (WORLD ROAD ASSOCIATION)

PIARC (the World Road Association) was formed in 1909. There are currently 108 country members; two thirds of which are developing countries. PIARC is a non-political and non-profit making association.

Vision - PIARC will be the world leader in the exchange of knowledge on roads and road transport policy and practices within an integrated sustainable transport context.

Mission - PIARC exists to serve all its members by:

- being a leading international forum for analysis and discussion of the full spectrum of transport issues, related to roads and road transport,
- identifying, developing and disseminating best practice and giving better access to international information,
- fully considering within its activities the needs of developing countries and countries in transition,
- developing and promoting efficient tools for decision making on matters related to roads and road transport.

PIARC Committee TC2.5 - Rural Roads and Accessibility

This is one of the technical committees of PIARC. The rural road surfacing issue is one of the topics on which Committee TC2.5 wishes to promote current knowledge exchange and dissemination.

Further information may be obtained from:- www.piarc.org

THIS WORKING PAPER

This working paper is one of the collaborative initiatives of the Low Cost Road Surfacing (LCS) programme (KaR7782) in cooperation with a number of sector experts working on research initiatives. This document is intended to provide guidance to senior policy makers, experts and practitioners in the Rural Road sector in economically emerging and developing countries (EDCs). The objective is to inform and provoke discussion, contributions and dissemination regarding surfacing aspects or rural roads. The LCS Project welcomes dialogue with engineers, managers, organisations, communities and individuals active or interested in the rural transport sector with the objective of the promotion of a sustainable rural access approach for EDCs.

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Sustainable Access Surfacing Techniques suitable for construction by Local Enterprises

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ABBREVIATIONS

ADT	Average Daily Traffic
ARRB	Australian Road Research Board
Bmb	Bamboo
BRC	Bamboo Reinforced Concrete
CBR	California Bearing Ratio
CSIR	Council for Scientific and Industrial Research (South Africa)
DCP	Dynamic Cone Penetrometer
DFID	Department for International Development
EDCs	Economically emerging and Developing Countries
esa	equivalent standard axles
FHWA	Federal Highways Association (US)
FM	Fines Modulus
FWD	Falling Weight Deflectometer
HDM4	Highway Development and Management Model
IFG	International Focus Group
ILO	International Labour Organisation
IRI	International Roughness Index
ITST	Institute of Transport Science and Technology
Km	kilometre
LCS	Low Cost Surfacing
MERLIN	**M**achine for **E**valuating **R**oughness using **L**ow-cost **IN**strumentation
MoT	Ministry of Transport
MRD	Ministry of Rural Development
MPWT	Ministry of Public Works & Transport
PIARC	World Road Association
QA	Quality Assurance
RRGAP	Rural Road Gravel Assessment Programme
RRST	Rural Road Surfacing Trials
RT2	Rural Transport 2nd Project, Vietnam
SEACAP	South East Asia Community Access Programme
SMEs	Small and Medium Enterprises
SOE	State Owned Enterprise
TRL	Transport Research Laboratory
VOCs	Vehicle Operating Costs
VPD	Vehicles per day
WLC	Whole Life Costs

5th International Focus Group for Rural Roads Engineering (IFG) meeting, Arusha, TANZANIA in March 2005.

TITLE: Sustainable Access Surfacing Techniques suitable for construction by Local Enterprises

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THEMES: **Technologies and Standards**

Participation of Community and Private Sector

ABSTRACT

The lack of year round access to many rural communities is a serious constraint to social and economic development, and poverty reduction. Poor access limits the effectiveness of agricultural, commercial, educational and health initiatives though unreliable travel and high unit transport costs for crops, goods, services and people. Previous rural transport initiatives have concentrated on the provision of gravel roads for all year rural access. However, experiences have shown that these roads, although relatively cheap to construct, are often an unsustainable maintenance burden for many road agencies and rural communities, and are rarely maintained in a serviceable condition. Dust from gravel roads in dry weather is also an environmental, health and safety problem and can adversely affect crops and property. The paper describes recent research on gravel road performance in Vietnam.

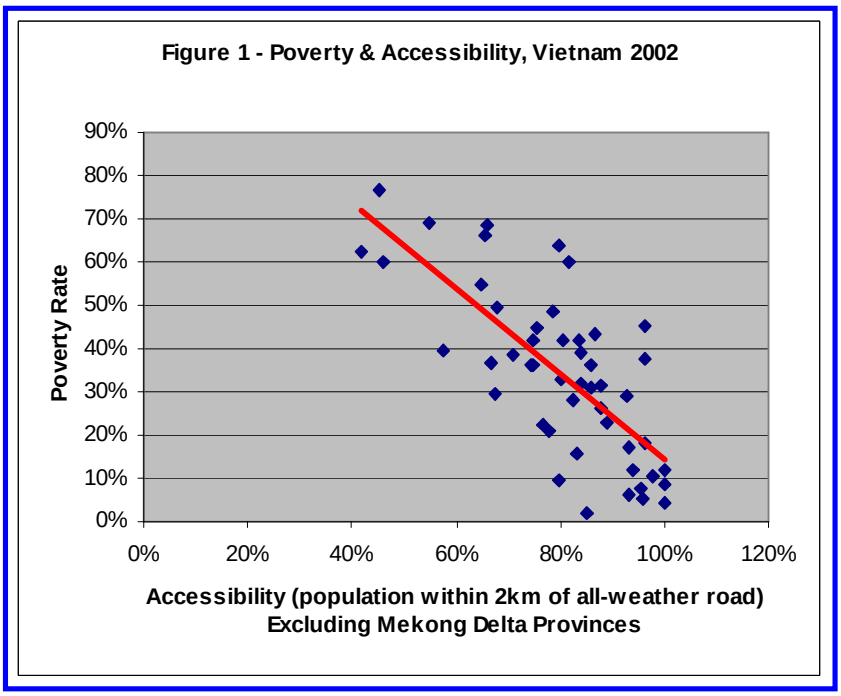
Furthermore, through other research programmes in Cambodia, Vietnam and elsewhere, a range of proven, low-cost, rural road paving options is identified. These are suitable for construction and maintenance by Small and Medium Enterprises (SMEs). Most of these paving options require little capital investment, use labour-based techniques and can optimize the use of local materials resources. They can utilize locally made simple equipment, thus promoting local manufacturing. For many of these techniques overhead costs are reduced and a higher proportion of the costs are recycled in the local community and therefore facilitate poverty reduction. The maintenance burden is usually lower than for gravel roads, and whole life costs can be cheaper than the provision of a gravel surface.

The paper also reviews the surfacing options and how they can be effectively mainstreamed in the rural road sector using Small and Medium Enterprises (SMEs).

KEY WORDS: SME, Rural, Road, Surface, Access.

1. BACKGROUND – THE CHALLENGE

In many developing countries, the main road network carries about 80 to 90 per cent of passenger and freight transport and it is, therefore, of key importance to the national economy. Main road networks are understandably given high priority in the allocation of investment and maintenance funds in recognition of their economic importance. Conversely, rural roads may make up over 80 per cent of the road network length, but are given lower priority in the allocation of funding because they carry much lower volumes of motorised traffic. Despite this, these rural roads are of vital importance to rural communities for their economic and social wellbeing and reduction of poverty. There is an established link between poverty and poor access (example Figure 1). Improved efforts must be made to improve the all weather accessibility of poor rural communities to help achieve the Millennium Development Goals.



Source: Vietnam 2002 Living Standards Survey

The rural poor do not have motor cars. However, they need reliable access for affordable transport or services (both motorised and non-motorised) such as bicycles, motorcycles, animal carts, minibuses, buses, whether owned or hired. Even if a bus ride is too expensive for them, they will still depend on the transporters that bring the medicine and teachers to the village, or carry crops etc. The essential challenge for engineers and road managers is therefore how to provide and maintain this rural access for the types of traffic currently in use, on a sustainable basis with the limited resources available.

Unsealed rural roads with earth and gravel/laterite surfaces comprise the greater proportion of the length of public roads in rural areas in developing regions[1]. Globally, they account for almost 60 per cent of the main road network, or about 1.2 million kilometres. In addition, there exists an estimated 5 to 6 million kilometres of designated minor roads and motorable tracks, and an extensive network of undesignated tracks and paths, probably several times the extent of the designated network[2].

Engineers have traditionally relied on the use of natural gravel/laterite as a rural road surface, due to its initial low costs and simplicity of use. However recent research[3] confirms the serious problems relating to maintenance and sustainability of such surfaces in many

1 Vietnam has a road network of approximately 210,000 km, of which over 100,000 km are to earth standard.
2 Paving the way for rural development & poverty reduction, Gourley, Greening, Jones, Petts, CAFEO 20, 2002.
3 Rural Road Gravel Assessment Programme investigations in Vietnam by Intech-TRL (SEACAP4).

situations common in South East Asia. This experience is valid for certain combinations of conditions in other regions. There are also health and environmental concerns regarding the widespread use of gravel.

2. THE LIMITATIONS OF GRAVEL

The word gravel is used within this document to denote any naturally occurring granular material, including laterite gravel, used as a road surfacing material. The experiences also apply in many circumstances to (often more expensive) graded crushed rock aggregate. Gravel is a 'wasting' surface. Material is lost from the surface of the road due to the action of traffic and rainfall. Natural gravel should only be used for rural road surface applications in situations where certain conditions are fulfilled. In general, **gravel should <u>not</u> be used where**:-

- **Gravel quality is poor** – Gravel should comply with grading and plasticity requirements, and not break down under traffic, otherwise it will be lost from the surface at a high rate. Natural gravel quality varies substantially within each pit location. Tests on placed gravel often demonstrate non-compliance with accepted grading requirements. Great care is essential to ensure that only suitable material is selected, and that mixing of marginal/unsuitable material is avoided,
- **Compaction & thickness cannot be assured** – uncompacted surface gravel will be less durable. Supervision arrangements should ensure that the full specified compacted thickness is placed,
- **Haul distances are long** – if haul distances are longer than 10km, then other surface types may be cheaper in whole life cost terms. Hauling gravel for construction and periodic maintenance causes damage or further maintenance liabilities to the haul routes,
- **Rainfall is very high** – Gravel loss is related to rainfall and may be excessive with intense storms or where annual precipitation is greater than 2,000mm,
- **There are dry season dust problems** – long dry seasons can allow the binding fines to be removed from the surface by traffic or wind. This is particularly problematic where communities live beside the road or their crops and property are regularly coated in dust. Inhalation of road dust is unhealthy and there are also visibility-safety issues,
- **Traffic levels are high** – gravel loss is related to traffic flows. It is unlikely that a gravel surface will be cost-effective at traffic flows of more than 200 motor (2 or more axles) vehicles equivalent per day.
- **There are Longitudinal Gradients** – Gravel should not be used in low rainfall situations (< 1,000mm/year) on longitudinal road gradients of more than 6%. In medium rainfall areas (> 1,000mm/year) gravel loss by erosion will be high on gradients of more than 4%. Above 2,000mm/year, rainfall related losses on any gradient are likely to be unsustainable.
- **Adequate maintenance cannot be provided** – Gravel is a high maintenance surface requiring both routine reshaping/grading and expensive periodic re-gravelling. Neither are achieved to adequate levels in many Emerging and Developing nations due to funding and operational constraints [4, 5] .

[4] In Cambodia it is estimated that a gravel rural road typically requires about US$1,600 per km per year for maintenance. These resources are simply not available on a national network basis - Rural Road Investment, Maintenance and Sustainability, A Case Study on the Experience in the Cambodian Province of Battambang, D Johnston and D Salter, May 2001.

- **Sub-grade is weak or soaked (flood risk) –** Weak subgrades require additional thickness of residual gravel to prevent traffic 'punching through' to the subgrade. Flooding can seriously damage gravel surfaces,

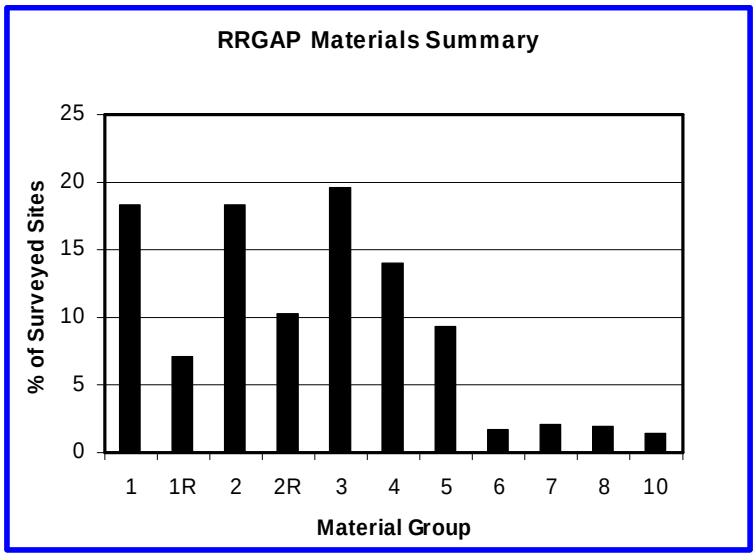
  or,

- **Gravel deposits are limited/environmentally sensitive** – Gravel is a natural and finite resource, usually occurring in limited quantities. Once deposits are used up, subsequent periodic re-gravelling will involve longer hauls and higher maintenance costs.

Even in simple combinations of some of the above factors, gravel can be lost from the road surface at more than 3cm per year, leading to the need to re-gravel at very frequent intervals[6]. The funding and resources are usually not available to achieve this and the surface will invariably deteriorate and revert to an earth surface.

3 RECENT RESEARCH IN VIETNAM

Intech-TRL have recently completed, as part of SEACAP[7], a condition survey of a representative selection of unsealed and gravel rural roads in Vietnam. This Rural Road Gravel Assessment Programme (RRGAP) survey, which included in situ and laboratory testing of the road materials, has been conducted on 269 roads and 766 cross sections constructed with a variety of natural and blended materials (Figure 2), in rainfall environments of between 850 and 3,000mm/year.



1	Laterite gravel
1R	Laterite + rock blend
2	Hill gravel
2R	Hill gravel + rock blend
3	Graded crushed rock
4	Non-graded crushed rock
5	Alluvial gravel
6	Gravel + clay blend
7	Weathered rock
8	Hand packed stone
10	Other

Figure 2 – RRGAP Range of Materials Employed as Unsealed Road Surfaces

Analysis of the initial results is now finalised. Previous concerns regarding a number of aspects of gravel road performance in particular circumstances have been verified with research data.

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5 Roads 2000, a programme for labour and tractor based maintenance of the classified road network, paper for the RMI road maintenance policy seminar, Nairobi 2 – 5, Petts June 1992

6 Required regravelling frequencies of 3 years or less are reported in some South East Asia locations.

7 SEACAP – South East Asia Community Access Programme, funded by DFID.

Some of the issues relative to the general use of gravel materials on rural roads in Vietnam and other regions experiencing medium to high rainfall environments include the following:

1. The main RRGAP investigations found serious constraints to the use of gravel in most of the studied 16 programme provinces due to factors relating to material type and quality, material availability, sub-grade condition, gradient, rainfall, drainage provision and maintenance. Overall gravel loss figures indicate that around **58%** of the surveyed sites are suffering unsustainable deterioration, while **28%** are losing material at twice the assessed sustainable limit of 20mm/year.
2. Gravel material loss from the road surface is highly variable (Figure 3). Many gravel roads have typically 80-90% of the road in fair to good condition after only a year or two of service, with some sections (10-20% of the length) in poor condition. This suggests a need to consider a spot improvement, or composite construction approach, in which at-risk or difficult sections are given a higher quality surface.

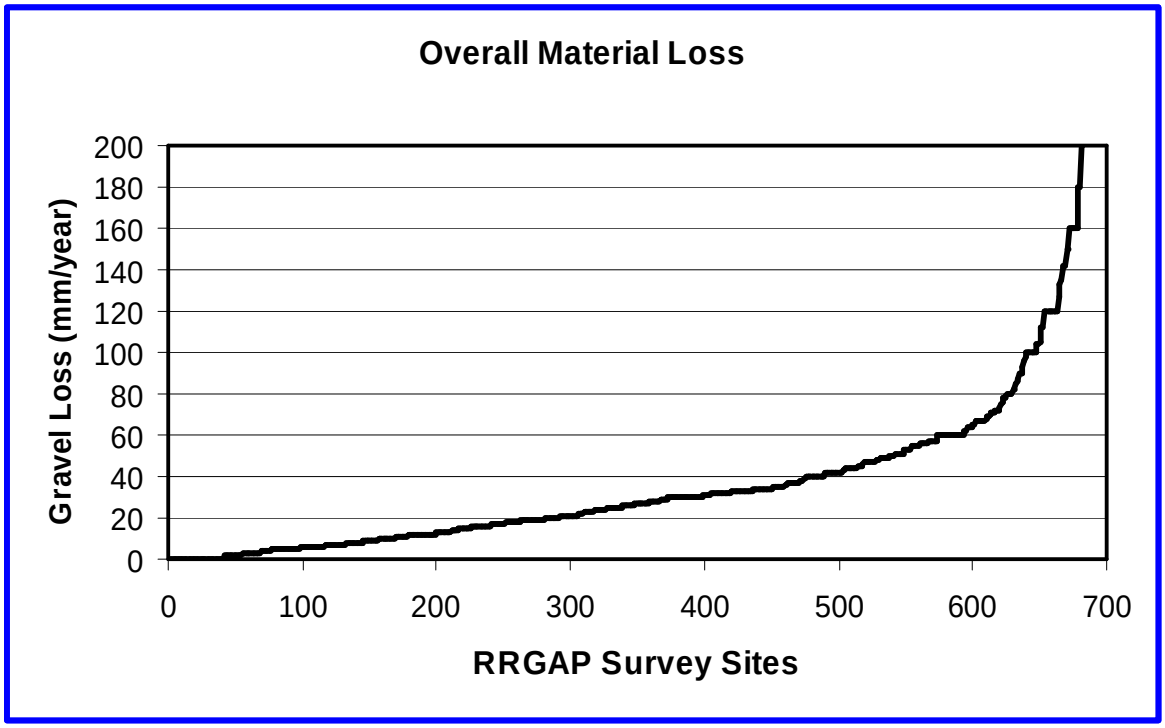

Figure 3 – Adjusted Apparent Material Loss Summary

Median	26 mm/year
%>20mm/year	58
%>40mm/year	29

3. Many of the gravel materials are not within widely accepted specification parameters. Hence a need to consider a design and quality assurance approach that specifies appropriate local materials rather than a blanket overall specification. Also a pragmatic approach is required to materials selection and approval, particularly in a remote location, constrained resource environment, lacking good testing facilities and arrangements.
4. At 60% of sites the camber or shoulder drainage was defective. Side drains were not provided where required at 52% of the sites. This suggests that more attention needs to be given to drainage provision at design and construction stages.

5. 75% of the surveyed roads have received no effective maintenance at all since construction. This emphasises the need either to construct road surfaces that are robust enough to withstand a low maintenance regime, or to put in place effective road maintenance arrangements that are not hampered by local funding or operational constraints, or skill and resource shortages. A coherent design and maintenance strategy is required, that recognises life cycle costs and the realities of local maintenance capacity and funding.
6. Two provinces outside of the RRGAP programme with very high rainfall (>3500mm/year) immediately overlaid the donor-sponsored gravel surfaces at their own cost, usually with concrete or bitumen penetration macadam. Besides the need for better surface selection procedures, this also suggests the possibility of a staged construction approach to some rural roads, in which an initial unsealed surface may be overlaid at a later date with an appropriate seal. Indications are that a gravel wearing course would not usually be suitable for this approach unless sealing was guaranteed to be undertaken within a short period, or certainly before the onset of the first rainy season in high rainfall areas. Certain stone applications would be more suitable.

It is clear that extensive awareness creation and training initiatives will be required to improve knowledge and decision making for policy makers, managers, engineers, contractors and communities regarding the challenges and constraints of the use of gravel and unsealed surfaces on rural roads.

4 PREVIOUS 'RULES OF THUMB'

Previous sector 'Rules of Thumb' indicated that gravel could be suitable for roads with traffic flows of between 50 and 200 motor vehicles per day (vpd). These guidelines suggested that earth roads would be suitable for traffic flows up to 50 vpd. However, such guidelines are extremely misleading, as some soils are totally inappropriate to support any traffic flows whatsoever. Furthermore, the criteria listed previously demonstrate that even gravel should never be considered for some combinations of conditions. Furthermore, research in Southern Africa has shown that low cost bituminous seals can be justified at flows of only 70 motor vehicles per day[8,9]. It is likely that full whole life costing of surface options will show that natural gravel is **NOT** the most cost-effective surface in most situations. It is necessary to be more rigorous in evaluating the options for rural and access road surfacing. Long hauls, high rainfall, high traffic, poor material, steep gradients, flooding, poor construction practices, lack of maintenance capacity and other extremes of condition will exclude gravel from being the most appropriate surface in many circumstances.

3. THE PROVEN ALTERNATIVES TO GRAVEL

Fortunately there is a range of proven alternatives to natural gravel. Some of these have similar initial construction costs to gravel in certain circumstances. Most have better whole life cost[10] attributes and lower maintenance liabilities.

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8 Performance of low-volume sealed roads: Results and recommendations from studies in southern Africa. TRL Project Report PR/OSC/167/99. Transport Research Laboratory, Crowthorne, Berkshire, UK, CS Gourley and PAK Greening, November 1999.

9 New approaches for the provision of low volume sealed roads. 20th Annual South African Transport Conference. Pretoria, South Africa, PAK Greening and CS Gourley, July 2001.

10 Whole Life Costs – discounted total construction and maintenance costs through the nominal life of the road.

Poor people often rely on non-motorised transport, motorcycles and simple trucks for their transport needs. On many soils, an engineered earth road is sufficient to provide basic access for these vehicle types, provided that specific, limited location constraints, such as watercourse crossings, weaker soil locations and steep gradients are adequately engineered with spot improvements. The camber and drainage must of course be maintained using appropriate, low cost techniques. Engineered Natural Surfaces therefore have enormous scope to improve access at very low costs for poor rural communities.

Engineers need to give greater attention to improving these basic access routes which often constitute more than 50% of the rural networks in developing countries. Low cost construction and maintenance techniques using local labour and simple equipment have an important role to play. These techniques are particularly suitable for implementation by small enterprises or communities. They use the locally available labour and have negligible capital requirements. Such Engineered Natural Surfaces (ENS) can be provided for less than US$2,000 per km in many situations, including the necessary low cost drainage measures[11]. Low cost grading of ENS can be achieved for as little as US$25 per km of grading using simple locally made equipment (Figure 4)[12].

However in some circumstances the in-situ soils are just too weak to support any traffic in the wet, and must be covered. For these situations, there is a range of alternative surfacing and paving options already proven in various countries that could provide appropriate, economical and sustainable alternatives to natural gravel in developing countries. Suitability will depend on local circumstances. These alternatives, involving the appropriate use of locally available materials, may be cheaper in whole-life-cost terms. Many can be carried out by small and medium enterprises using low-capital, labour based and light equipment methods.

Figure 4 - ENGINEERED NATURAL SURFACES:
Maintainable using simple locally made equipment

Communities themselves could use some of the techniques to improve their own access. The alternative surfaces should have lower (and more manageable) maintenance requirements than gravel, not only in terms of cost but also by reducing the need for (imported) heavy equipment to transport and compact. Their environmental impact could be substantially less.

The rural road surfacing options are summarised in Figure 5. These are all proven surfacing techniques. Guidelines on the use of these alternative surfaces and pavement layers have been compiled and successfully implemented in a number of countries. Outline guidance on the application of the various surface types is also indicated in Figure 5.

11 For example, Kenya ***Roads 2000*** network experiences.
12 For example, Cambodia and Zimbabwe experiences.

Figure 5

RURAL ROAD SURFACING GUIDELINES

Draft

Options Menu - Using Local Resource Based Methods
Focusing on the use of local labour, materials, enterprises and the community themselves.
Broad suitability guidelines are indicative only - dependant on site conditions and environment.

Number	Type of Surface	SUITABILITY FOR TRAFFIC As a Road Surface		
		Light	Medium	Heavy
1	Engineered Natural Surface			
2	Soil Stabilisation			
3	Natural Gravel / Laterite			
4	Water Bound Macadam			
5	Dry Bound Macadam			
6	Crushed Stone Macadam			
7	Hand Packed Stone			
8	Telford Paving			
9	Cobble Stones			
10	Stone Setts or Pavé			
11	Dressed Stone			
12	Mortared Stone			
13	Stone Chippings			
14	Slurry Bound Macadam			
15	Bituminous Sand Seal			
16	Bituminous Chip Seal			Note 3
17	Slurry Seal			Note 3
18	Ottaseal			
19	Penetration Macadam (Bitumen)			
20	Pre-Mix Macadam (Bitumen)			
21	Burnt Clay Brick			
22	Concrete Brick			
23	Un-reinforced Concrete			
24	Steel Reinforced Concrete			
25	Bamboo Reinforced Concrete			
26	Geo-cell Paving			

	Type of Roadbase or Subbase	*Application suitability depends on various factors.*
1	Soil Stabilisation	
2	Natural Gravel / Laterite	
3	Water Bound Macadam	
4	Dry Bound Macadam	
5	Crushed Stone Macadam	
6	Hand Packed Stone	
7	Telford Paving	
8	Slurry Bound Macadam	
9	Sand Aggregate	
10	Armoured Laterite	
11	Pulverised Fuel Ash	

Traffic

Light:	Mainly non-motorised, motorbikes & less than 25 motor vehicles per day, with few medium/heavy vehicles
Medium:	Up to 100 motor vehicles per day including up to 20 medium (10t) goods vehicles
Heavy:	Accessible by all vehicle types including heavy and overloaded trucks

Notes

1. Assumes that adequate specifications, thickness & foundations are provided for each surface type.
2. Engineered Natural Surface suitability depends on soil type and environment
3. Suitable for Heavy Traffic in Multiple Seal applications

Approximately half of these techniques have been or are currently being investigated and demonstrated on the Cambodia and Vietnam Rural Road Surfacing Trials managed by Intech Associates and TRL. Plans are being prepared to extend the trials to other surface types and environmental locations. When initial research and monitoring of these trials is completed later in 2005, Intech Associates-TRL will be preparing guidelines on their use and for mainstreaming the techniques. For Cambodia and Vietnam the intended objective is the revision of the rural road surfacing standards.

Figure 6

4. SUITABILITY FOR SMALL & MEDIUM ENTERPRISES (SMEs)

The rural transport sector in many developing countries is characterized by the dominance of large construction enterprises using capital intensive methods for construction and maintenance works. These contractors have high overhead costs and their mobilization to the rural areas is expensive. Small and Medium Enterprises (SMEs) are generally poorly developed and have limited opportunities to penetrate the market.

However, if encouraged, SMEs would be particularly well suited to carrying out rural road construction of the alternative surfacing options due to:

- Possibility to be based in the rural areas with low mobilization costs,
- Low capital and set-up requirements,
- Inter-sector flexibility; possibility to provide services to a range of sectors and clients,
- Good market entry point for small entrepreneurs,
- Possibility to use affordable simple equipment, either owned or hired,

- Possibility to use local labour skills such as carpentry and masonry,
- Less pressures for corrupt practices, as they are part of the local community,
- Less opportunities for HIV-Aids infections due to less imported labour into the community,
- More of the costs recycled into the local community in employment of local labour, local tools production, local transport, local materials and profits,
- Construction skills developed in the local community which can be utilized for maintenance and other activities,
- Low overhead costs.

However, investigations in many developing countries (References 6, 13, 14, 16) and the trials themselves have shown that these enterprises often suffer from a number of constraints that prevent them from establishing, surviving and delivering low cost infrastructure services and sustainable road surfaces to the rural communities. These constraints include:-

- Barriers, bureaucracy or costs of establishing SMEs,
- Inadequate Government policy framework to support the SME sector for rural roads,
- Insufficient public awareness of the potential benefits of SME rural road works implementation,
- Lack of appropriate contract documentation, pre-qualification & bidding procedures, financial and performance audit, dispute resolution for small scale works, in place,
- Lack of national standards and specifications to allow the widespread design and use of the alternative paving options,
- Contract pre-qualification too demanding, e.g. 3 years experience of similar work,
- Contracting procedures and requirements usually (unnecessarily) demand heavy equipment holdings,
- Lack of access to capital or credit for equipment purchase or cashflow,
- Lack of opportunities to hire equipment,
- Poor contractors' capacity in costing and planning works,
- Inadequate access to low cost training and guidelines on small scale road works,
- Contract technical solutions are usually restricted to gravel and macadam surfaces,
- Lack of sustainable local funding for small rural road works contracts and maintenance,
- Lack of market and sustainable workload for SMEs,
- Lack of representation of SMEs (e.g. business association),
- Late and/or non-transparent payments for locally funded work,
- Corruption in award and payment for work.

The national sector stakeholders must cooperate to overcome or minimise these constraints, drawing where possible on the experiences and support of overseas partners and the knowledge and experiences of sector experts.

5. CONCLUSIONS

A range of proven, low-cost, rural road paving options exist as an alternative to the use of problematic natural gravel as a road surface. The low cost paving options usually have a number of economic, social, health and environmental advantages over gravel. These alternative paving techniques are suitable for construction and maintenance by Small and Medium Enterprises (SMEs). Most of these paving options require little capital investment, use local resource based techniques and can optimize the use of local materials. However

there are a number of constraints that currently prevent these approaches from being widely used in developing countries. Initiatives are required to be taken by governments, road authorities, contractors' associations and donor agencies to tackle these constraints to develop a vibrant market for rural infrastructure works and enable SMEs to establish and survive to deliver low cost, sustainable road infrastructure solutions to the rural communities. This would provide an important improvement in the prospects for social and economic development, and rural poverty reduction for these communities.

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