NATIONAL WORKSHOP ON
ROAD PLANNING,
AXLE LOADING AND
PAVEMENT DESIGN STRATEGY

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WORKSHOP PAPER No 8

LESSONS LEARNED FROM THE POUK LOW COST SURFACING TRIAL

SIEM REAP PROVINCE – CAMBODIA

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AFEO	Asian Federation of Engineering Organisations
ASEAN	Association of Southeast Asian Nations
AusAID	Australian Agency for International Aid
CFRTD	Cambodia Forum for Rural Transport Development
CNCTP	Cambodia National Community of Transport Practitioners
CSIR	Council for Scientific and Industrial Research
DFID	Department for International Development
DST	Department of Science and Technology
DTW	A Mechanical Engineering NGO
EDC	Economically emerging and Developing Country
EU	European Union
FAO	Food and Agriculture Organisation
FFW	Food For Work
GMSARN	Greater Mekong Sub-region Academic & Research Network
GTZ	German Agency for Technical Co-operation
HQ	Head Quarter
IFG	International Focus Group (for Rural Road Engineering)
IFRTD	International Forum for Rural Transport Development
ILO	International Labour Organisation
IRAP	Integrated Rural Accessibility Planning
IRD	Integrated Rural Development
JFPR	Japanese Fund for Poverty Reduction
JICA	Japanese International Co-operation Agency
KaR	Knowledge and Research
km	kilometre
Koyun	Locally assembled light truck
LB	Labour Based
LBAT	Labour-Based Appropriate Technology
LBRIRMP	Labour-Based Rural Infrastructure Rehabilitation and Maintenance Project
LCS	Low Cost Surfacing
M	metre
MEF	Ministry Economic and Finance
MPW&T	Ministry of Public Works and Transport (Cambodia)
MRD	Ministry of Rural Development (Cambodia)
NCP	National Community of Practitioners
NFG	National Focus Group (for Rural Road Engineering)
NGOs	Non-Governmental Organisations
NPA	Norwegian People's Aid
NPRD	National Programme to Rehabilitate and Develop Cambodia
NRDP	North-Western Rural Development Project
ODA	Official Development Assistance
PDP	Provincial Development Programme
PDRD	Provincial Department of Rural Development
PIARC	World Road Association
PIP	Public Investment Programme
PMU	Project Management Unit

PRDC	Provincial Rural Development Committee
PRIP	Provincial and Rural Infrastructure Project
RD&RP	Rural Development and Resettlement Project
RDS	Rural Development Structure
RGC	Royal Government of Cambodia
RIIP	Rural Infrastructure Improvement Project
RRGAP	The Rural Road Gravel Assessment Programme
RRSR	The Rural Road Surfacing Research
RRST	Rural Roads Surfacing Trials
SEACAP	South East Asia Community Access Programme
SEDP I	First Five-Year Socio-Economic Development Plan, 1996-2000
SEDP II	Second Five-Year Socio-Economic Development Plan, 2001-2005
SEILA	Multilateral donors - Government Rural Infrastructure Development Programme
SIDA	Swedish International Development Agency
SWOT	Strengths, Weaknesses, Opportunities & Threats
TDSI	Transport Development Strategy Institute
TEDI	Transport Engineering Design Incorporation
TKP	Transport Knowledge Partnership
TMP	Transport Mainstreaming Partnership
ToR	Terms of Reference
TRIP	Tertiary Roads Improvement Project
TRL	Transport Research Laboratory
UK	United Kingdom
UN	United Nations
UNCDF	United Nations Capital Development Fund
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
VDC	Village Development Committee
WB	World Bank
WFP	World Food Programme
WSP	A firm of International Management Consultants
ZOPP	German acronym for Goal Orientated Project Planning

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 and South East Asia Community Access Programme (SEACAP). The initiative is led by UK-based specialist consultants Intech Associates in association with TRL Ltd. Collaboration has been established with a number of organisations with interests or experience in the sector, including 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 being implemented over a 4 year period from 2001 to 2004.

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.

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 will provide 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 are part of the DFID's Knowledge and Research programme, whilst Project 3, is 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

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

TRANSPORT KNOWLEDGE PARTNERSHIP

The Transport Knowledge Partnership (TKP) is a global initiative that has the broad aims of making knowledge more accessible to its partners, providing a global transport resource, and encouraging a greater up-take of existing knowledge. A main principle of TKP is that it will work in support of existing initiatives and structures. TKP will also work principally for the benefit of developing countries, giving them greater voice in the way that knowledge is generated and managed, and providing them with greater and more appropriate access to knowledge. IFG is one of the TKP partners.

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

CAMBODIA NATIONAL COMMUNITY OF TRANSPORT PRACTITIONNERS (CNCTP)

The Cambodian National Community of Transport Practitioners on Rural Road Engineering was formed to provide a forum in which key technical issues relating to planning, design, construction, and maintenance of rural roads can be discussed and advanced among practitioners of rural development, relevant information exchanged, and gaps in knowledge identified. Initially the CNCP was established to guide and enhance the implementation of research projects funded by the UK Department for International Development (DFID) being undertaken by the Transport Research Laboratory (TRL), ILO/ASIST, and INTECH Associates in collaboration with partners in Africa and Asia; and to coordinate the Regional Cooperation between Cambodia and Vietnam under the South East Asia Community Access Programme (SEACAP).

However since the scope of interests and activities of the CNCP has widened since the First Meeting convened at the Ministry of Rural Development (MRD) in July 2003. At the Second Meeting of CNCP held at MRD in August 2003 a wider remit for the Group was debated and unanimously adopted. The vision is to be the leading platform for articulating and disseminating information on rural road engineering within the context of poverty reduction. CNCP shares a concern for rural road engineering among practitioners. It provides a platform for discussion, exchange of knowledge and identification of knowledge gaps on key

engineering issues relating to planning, design, construction and maintenance of sustainable rural roads in the country.

The Cambodian National Community of Practitioners aim to:

- Provide a leading platform of partnerships and knowledge exchange both nationwide and internationally
- Act as a focal point for research (initiation, execution and application)
- Ensure coherence and coordination for an effective dissemination of information on best practices and research outputs
- Facilitate the application of research outputs
- Mainstream best practices in rural road engineering to meet sustainable transport access needs in support of poverty reduction objectives.

INTRODUCTION

By the end of the Khmer Rouge era, Cambodia had lost approximately 75% of its road network, and 75% of its teachers; both tragic impediments to the social and economic development of Cambodia.

During the civil war within the nation, people had relied on rich natural resources such as forest, fishing, fertile agriculture land, cultural and environmental tourism heritage etc… With over-exploitation and the constant population growth the country's resources are now exhausted. It should be clearly understood to all Khmer that people in this country will no longer be able to rely on the heritage of natural resources for supporting their livelihoods. Sustainable development and employment is vital for the survival of people in this country. In order to achieve this dream, not only the government but politicians, Cambodian specialists, economists, educators, engineers, technicians…have to be actively involved helping each other.

The experience and knowledge gained on alternative surfaces may give substantial support to road authorities, economists and policy maker to move away from reliance on gravel/laterite surfacing, which is problematic and unsustainable for many situations in Cambodia. Gravel use was a necessary immediate, rapid-impact response in the post-conflict situation, in an effort to provide access to as many poor communities as possible. However, the Government can now plan more sustainable paving options in all of our rural road programmes, based on the Puok Trial experiences. These include World Bank, Asian Development Bank and bilateral agency funded programmes. Those projects expect to achieve sustainable access for poor people in rural and remote areas through use of local materials, local labour (creating employment) and encouraging local ownership and reduced maintenance burdens for the communities and RGC.

Previous experiences had shown that many paved and unpaved roads were deteriorating faster than expected or sometimes, the road could not even survive the first rainy season after reconstruction works finished. This has caused the government unnecessary expenditure resulting in the re-investment of their limited and scarce funding in reconstructing the same road several times.

There are many factors relating to this rapid chronic cycle of deterioration. These include lack of primary data, limited resources and time dedicated for necessary study and data collection for long term planning and engineering design, substandard design due to limited resources, diversion from the design with construction characterised by poor quality control management and corruption, lack or absence of maintenance etc.. But there is one

predominant factor, that of **overloading,** which needs to be considered and brought under control.

The failure of some of the trial sections is just one example of road pavements which have been damaged by heavily overload vehicles. But there are undoubtedly many more roads both paved and unpaved that have not been reported by the responsible authorities.

The failure of section 4 and section 9 of the Puok trials were just 200 meters long road sections damaged by grossly overloaded vehicles, and even though many efforts were taken by the research engineer to inform and ask for intervention from the authorities at all levels. However no action was taken to stop the trucks.

With all the problematic issues of laterite road surfacing and the maintenance burden, the government is now moving towards more sustainable paving options and thus there will many more paved roads being built and being subjected to overloaded traffic.

The Author expects this paper will contribute in drawing attention to those involved authorities to realize the extent and risk of pavement deterioration due to overloading.

For sustainable access, overload traffic must be brought under control.

THIS PAPER

The paper describes all factors which led to failure of some sections of the DFID – ILO Cambodia supported trials. It provides details of deterioration evolution, causes and responses from the project engineer.

This report is an output from a series of field investigations and observations, interviews with local people and negotiations carried out at Pouk District Office consultant's team, district authority and sand-haulage company discussing repair-works, contribution and further establishment of pragmatic maintenance management and a reporting system specifically to look after the LCS trials in the future.

This material is intended to be used as support documentation for provoking discussion and sharing previous experiences between road authorities, provincial and local government, development and funding agencies, NGOs, donors, consultants, road users, road engineers and practitioners during the workshop.

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.

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CAMBODIA LOW COST SURFACING PHASE 2

ON

ROAD PLANNING – PAVEMENT DESIGN & OVERLOADING PREVENTION WORKSHOP

WORKSHOP PAPER-No 8

LESSONS LEARNED FROM THE CAMBODIA LOW COST SURFACING TRIALS

First Edition: December 2004

1 THE LCS BACKGROUND

Under the KaR 7782 Project Phase 1, investigations have been carried out and guidelines are being developed on alternative low cost rural road surfaces, which in appropriate circumstances will have lower whole-life-costs than gravel. The alternative surfaces can also have better local resource use attributes; with the effect of injecting more of the road works costs into the local community through labour employment, use of local materials and enterprises.

The LCS trials have been one of the first attempts to construct quality pavements using labour-based appropriate techniques in the region. The majority of literature and resources currently available in relation to labour-based road construction is predominantly concerned with gravel roads.

The aim of the paving trials was to investigate and demonstrate the construction of a range of paving techniques as an alternative to gravel/laterite, suitable for secondary and minor roads using local-resource-based techniques wherever possible. The trials will also be the basis of assessing whole life costs of the various paving options. The rationale for investigating alternatives to gravel/laterite is contained in LCS Working Paper No 1.

A core goal of the trials was the assimilation of knowledge not only for the engineers, organisations and ministries involved in the implementation of the project but also for the SSCs, workforce, local communities and local professional staff. In this way the trials have offered an insight into current engineering, social and economic issues of prominence within the sector.

As part of the Phase 1 work, 10 sections of alternative paving were constructed at Puok Market, Siem Reap Province in Cambodia on a tertiary rural route. The Puok Market paving trials have been constructed under a cooperation initiative between Intech Associates, ILO Upstream Project, Ministry of Public Works & Transport and Ministry of Rural Development, Cambodia, with principal funding from DFID and SIDA. Two local contractors, using the minimum of equipment and the maximum input of local unskilled and skilled labour, constructed the trials in mid 2002.

The construction of the Puok Market trial sections were completed in September 2002. There were 10 different sections comprising of the following options:

Section 1	Bamboo Reinforced Concrete Pavement
Section 2	Sand-Aggregate Roadbase & Single Bitumen Stone Chip Seal
Section 3	Dressed Stone with Bitumen-Sand Sealed Joint
Section 4	Armoured Laterite Roadbase & Single Bitumen Stone Chip Seal
Section 5	Dressed Stone Pavement & Bitumen-Sand Seal Joint
Section 6	Sand-Aggregate Roadbase & Single Bitumen Stone Chip Seal
Section 7	Telford Water Bound Macadam & Single Bitumen Stone

	Chip Seal
Section 8	Water Bound Macadam & Double Bitumen Stone Chip Seal
Section 9	Armoured Laterite Roadbase & Sand Seal
Section 10	Hand-Packed Stone & Laterite Wearing Coarse

In April-May 2003, initial monitoring of the trials was carried out and they were found to be in good condition with no serious defects. The construction was found to have been largely in accordance with the design intentions. The trials have successfully proven that higher class pavements may be constructed using labour-based methods. A source of valuable engineering and practical construction knowledge is now at hand. Labour constructed paving can now be extended with confidence to secondary, main and urban paving situations, bringing economic and social benefits to the communities and local enterprises.

During the mid year wet season, the Puok Trial sections have been subjected to significant numbers of sand haulage trucks. It was apparent that these trucks are heavily overloaded, hauling wet sand, and used the road on a regular daily basis.

The Project engineer had discussions regarding this overloaded truck with the authorities at district level, Provincial (PDRD) and Central level (MRD). However, there were no effective actions taken to stop the heavily overloaded trucks.

With heavy trucks continuing to access the trial section, there was no possible engineering solution to repair and stop the damaging progress under such a busy trafficked road. It had been observed that trucks passed the road almost every half hour at that time.

The result, up to end of the rainy season, December 2003, has been that 80% of section 4 and 20% of section 9 of the trials became severely damaged and other sections also showed signs of distress.

2 PAVEMENT STRUCTURE AND EXPECTED SERVICE LIFE

2.1 INITIAL MONITORING & EVALUATION (APRIL-MAY 2003)

Project engineer and trainees from MRD, MPW&T and ITC conducted a series of tests for the evaluation.

Analysis of the data collected during the initial monitoring phase of the LCS project lead to evaluation of each paving option, prediction of the deterioration evolution and determination of the most appropriate maintenance techniques for each pavement type and the associated costs.

All of the Puok Market trials sections were found to be in good condition with no serious defects. The construction was found to have been largely in accordance with the design intentions.

Analysis of the data collected (CBR and Deflection…) during the initial monitoring phase of the LCS project had lead to an estimation of the pavement life in terms of total number of equivalent standard axles (ESAs) which each pavement may be subjected to from the monitoring and evaluation time up to the need for major operation required such as general overlay.

For section 4 and section 9, it had been estimated to be able to carry traffic for at least 10^5ESAs. Detailed pavement structure of sections 4 and 9 are given by the Figure following.

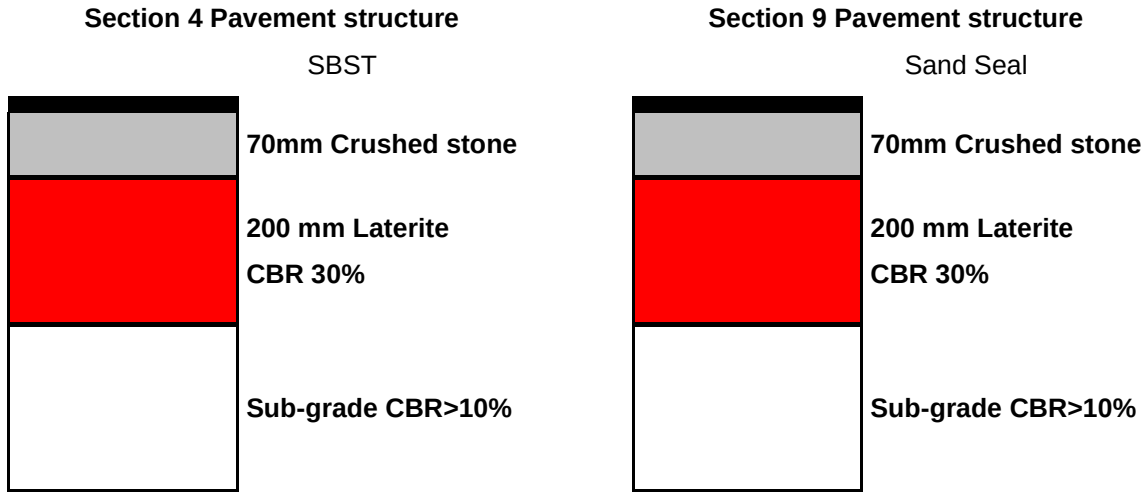


Figure 1: Pavement structures of Sections 4 and 9

These two sections have similar pavement design, thickness and material. The difference is that section 4 is paved with single bituminous emulsion surface treatment while section 9 is paved with bitumen emulsion sand seal. The aim of having this difference is to compare the performance between SBST and Sand Seal.

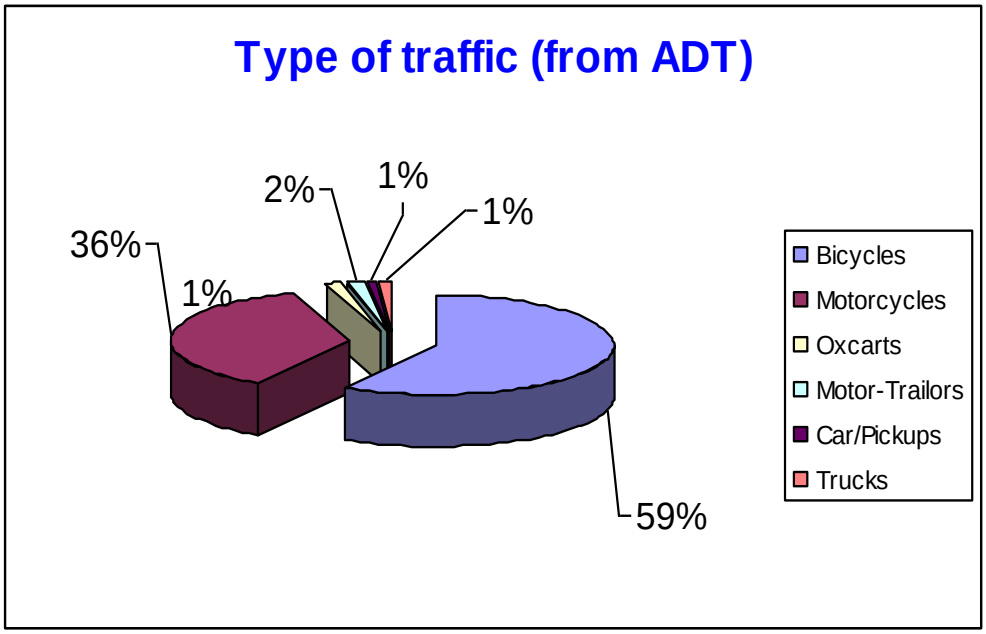
2.2 POUK TRIAL TRAFFIC

Pouk Trial road is a fairly busy rural road and its traffic is composed of non-motorized and motorized vehicles. However vehicles such as bicycles, motorcycles and cars have no or very little effect on pavement deterioration. (Figure-2 gives traffic composition of the Pouk LCS Trial Road in percentages after conversion to Passenger Car Units).

Thus for predicting pavement deterioration, only vehicles of unladen weight of about 3T or more will be counted. With this regard, the traffic on this road is found to be moderate, 150 ADT of commercial vehicles per day.

This ADT comprises mainly light vehicles e.g. the locally made Koyun and the light Korean made trucks (5T pay load). They transport commodities, agriculture products and local people from their village to Pouk market and vice versa. There are also small trucks carrying goods such as firewood, wooden pillars, and construction materials such as earth, clay brick, of which the axle load is rarely exceeding 6T for the Koyun and 8T for the small Korean truck. (Refer to Table-1 and Table-2).

Figure 2: Traffic Composition of the Pouk Trials counted in November 2002 (Source ILO-Upstream Project)



Note: The term "truck" represents small and medium commercial vehicles and the locally made Koyun. There were rarely heavy trucks using this road.

Table 1: Axle Load Survey on Pouk LCS Trial (Rural Road)
23 to 30 April 2003

Date	Start Time	Finish Time	Total number of two/more axle motorised vehicles (>3 T)	Total ESAL	Mean ESAL
23/04	07:40	18:30	68	23.5	0.346
24/04	06:45	12:20	54	13.3	0.247
25/04	07:25	18:50	91	78.4	0.862
26/04	06:54	19:01	25	4.0	0.114
27/04	07:00	18:55	42	26.6	0.632
28/04	06:40	18:55	134	25.7	0.191
29/04	06:40	18:50	148	83.2	0.562
30/04	06:30	18:50	92	12.6	0.136
Average Mean ESAL per Vehicle (A_{ESA})					**0.39**

Table 2 : ESA per vehicle on National Road		
2 Axle Truck	*3 Axle Truck*	*3 Axle Truck +Trailer*
1	*2*	*3.5*
Note: After Axle load survey on National Road under Transport Network Improvement Project TA No2722-CAM Final Report – June 1999		

Typical Transport utilizing the LCS Trial Road

2.3 EXPECTED PAVEMENT LIFE & MAINTENANCE REQUIRED

With the relatively strong pavement found after the deflection survey and with light traffic, the engineer expected that traffic should not be a predominant factor to pavement deterioration and climatic factors should take a few years before causing any defects to occur on these trial sections.

However the engineer identified some problems eg. edge step and erosion along the laterite shoulder that would require repair-works regularly. This problem was caused by the ox-cart's thin steel wheels and vehicle tyres driving on this low strength part "Edge of pavement" while overtaking or crossing from opposite directions.

3 START OF SAND EXTRACTION & COMMENCEMENT OF PAVEMENT DETERIORATION

On 25th August 2003, The research engineer urgently visited the site after receiving a warning call informing him about signs of distress that had occurred on certain sections reported by a road engineer who was unintentionally travelling along the trial road.

When the engineer arrived, there were many trucks empty in one direction and returning fully loaded with wet sand driving through the Trials towards Siem Reap town as a final destination. The Sand quarry was opened late May 2003, at the beginning of the rainy season.

After investigation, it was found that there were minor cracks affecting two small areas of about 10 sq. metres on Section 4 and importantly rutting occurred on the wheel tracks of this section. Section 9 was also showing signs of distress with important rutting that had developed but there were no cracks. The Project engineer had discussions with the authorities at District Level regarding the overloaded trucks, Provincial (PDRD) and Central level (MRD). However there were no solutions forthcoming to stop these heavily overloaded trucks.

Sand extraction quarry

On 13th September 2003, the Project Engineer revisited the road site, and it found that 40% of section 4 was severely damaged and Section 9 had been affected with major cracking for an area of 10 sq. metres. With heavy trucks continuing to access the trial sections, there were no possible solutions to repair and stop the damaging progress under such a busy trafficked road. There were trucks passing almost every 20 minutes.

In October 2003 an assessment of the condition of trial pavements was undertaken, by Intech Associates and reported in LCS Working Paper 18.

In late January 2004, Intech Associates technical team re-visited the trial site. 80% of section 4 paving was completely broken and 20% of section 9 affected with crocodile cracking. The principal activities undertaken are summarised in the following section.

On 25th August 2003

13th September 2003

4 WORK UNDERTAKEN: JANUARY - FEBRUARY 2004

4.1 Scope

An Intech Associates technical team comprising, Engineers Rob Petts, Heng Kackada and Dr Jasper Cook, visited the trial site between 21st and 24th January 2004. The principal activities undertaken are summarised as follows;

- Discussions with Puok District officials on traffic, road repair and maintenance issues
- Assessment of the trials surface conditions and also the adjacent ILO bamboo reinforced concrete road section
- Assessment of locally available construction materials.

4.2 District-Level Discussions

Discussions were held with the Puok District Authority officials and the owner of the transport company responsible for trafficking the trial roads with overloaded sand haulage trucks. The meeting took place on 21 January 2004.

The trials pavement damage had been caused principally by 17 – 20 m³ truck struck body capacity, 3 axle trucks hauling wet sand from a new pit opened up in the area which the trials road provides access for. A visit to the sand pit allowed an estimate of the quantity of hauled material to be assessed. This was calculated to be approximately 30,000 tonnes.

Part of the Sand Pit area

After discussions it was agreed that:

1. the sand haulier would make a payment of US$1,300 towards the repairs of the damaged road. It was accepted that the damage was not all the fault of the principal sand haulier. The agreed amount was paid to Intech Associates to hold until the repair works could be organised.
2. the usage of the route by overloaded trucks would be discontinued by agreement between the haulier and the local authority.
3. It was agreed that Intech Associates would meet the District Maintenance Committee on a future visit, to discuss the rehabilitation of the trial road and also maintenance arrangements for the route.
4. Physical obstacles were envisaged during the meeting as an efficient solution to stop heavy trucks

Even though the company has contributed to the repair of the failed section of the Pouk Trials, however there were no corrective works regarding the 5 Kms length laterite road built

by ILO-Upstream project which had also been heavily damaged from the quarry up to the end of the trial sections.

Note: The District Maintenance Committee comprises the following persons:-

Deputy District Chief (chairperson)	District Engineer
Member of Police	District Accountant
District Woman's Affairs representative	A monk (Honorary)
District Military representative	District Customs Dept. representative
All commune chiefs	Director PDRD

5 LESSONS LEARNED FROM FAILURE OF SECTION 4 AND SECTION 9

The principal conclusions to be drawn from monitoring of the LCS Trial

- **Engineering Issues**
  - The majority of vehicles accessing this rural road have low axle loading and rarely exceed the conventional pavement design axle load, 8T. If occasional oversized and heavy trucks are effectively prohibited from a route, then cheaper paved roads can be built and maintained.
  - The designs of Sections 4 and 9 are strong enough for light rural traffic loadings such as Pouk market trial. But they are well below the strengths required for heavy commercial traffic, and even more so for the grossly overloaded sand trucks that are currently using the road. However it should be noted that only 20% of Section 9 was damaged. The other 80% of Section 4 remains in good condition.
  - The rapid deterioration of Section 4 pavement, and the onset of Section 9 deterioration, is primarily the result of excessive traffic loading.
  - The stone block Sections 3 and 5 have continued to perform well under heavy axle loading, although some localised depressions have been identified.
  - The ILO concrete road and double seal sections have stood up well to the heavy traffic loading apart from two slabs.
  - The heavier load spreading options such as the reinforced concrete, the dressed stone surfacing and thick aggregate road-base with double bituminous seals may have a better chance of resisting the impacts of the overloaded sand trucks.
- **Institutional and Management Issues**
  - Lack/No clear responsibility for road and loading management
  - The road authority is not yet prepared to respond to overloading of vehicles.
  - Absence of Ownership and Participation/collaboration from the local community/authorities.
- **Economic**
  - With low traffic volumes, it is sometimes difficult to prove economic justification (IRR 12%) for a low volume sealed road project. However, the Low Cost Surface Options would increase the benefit by generating the employment both direct and indirect, and minimize foreign exchange.

- If the overloading issue cannot be solved, low volume sealed roads must be designed as strong as busy roads and the investment becomes very expensive. This means that the project cost has to increase more than 50% for a little gain from 1% of the traffic that is heavy trucks.

❖ **Social**

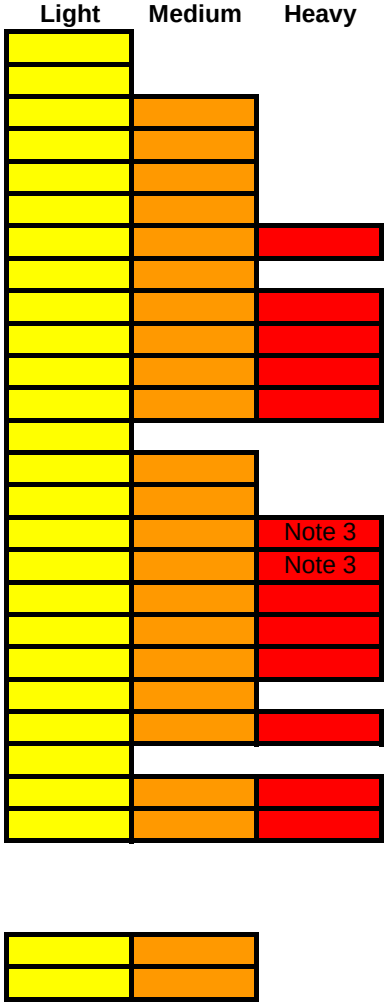
- By employing local people to build their roads this will encourage ownership and local participation.
- The Transfer of knowledge during construction will benefit further maintenance initiatives.

ANNEXE: LIST OF RURAL ROAD SURFACING GUIDELINES

RURAL ROAD SURFACING GUIDELINES

Using Local Resource Based Methods
Focusing on the use of local labour, materials, enterprises and the community themselves.

Number	Type of Surface or Road base	SUITABILITY FOR TRAFFIC As a Road Surface
		Light / Medium / Heavy
1	**Engineered Natural Surface**	
2	**Soil Stabilisation**	
3	**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**	
	Type of Roadbase	
26	**Sand Aggregate**	
27	**Armoured Laterite**	



Definitions

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

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