MINISTRY OF PUBLIC WORKS AND TRANSPORT

TRIALLING THE NEW STANDARDS AND SPECIFICATIONS AND EXTENDING THE LAO LVRR SURFACE AND PAVING KNOWLEDGE BASE

June 2009

TRIALLING THE NEW STANDARDS AND SPECIFICATIONS AND EXTENDING THE LAO LVRR SURFACE AND PAVING KNOWLEDGE BASE

FINAL REPORT
JUNE 2009

Prepared for: Project Record: **SEACAP 3.02-SEACAP 31.**

	Approvals
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Quality Reviewed **S Done**	

CONTENTS

ABBREVIATIONS & ACRONYMS

ADT	Average Daily Traffic
ASEAN	Association of South East Asian Nations
CRC	Community Road Committee
DBM	Dry Bound Macadam
DBST	Double Bituminous Surface Treatment
DPWT	Department of Public Works and Transport (Province Level)
DCP	Dynamic Cone Penetrometer
DfID	Department for International Development
DoR	Department of Roads
EADT	Equivalent Average Daily Traffic
ENS	Engineered Natural Surface
EOD	Environmentally Optimised Design
esa	equivalent standard axles
GOL	Government of Lao PDR
gTKP	global Transport Knowledge Partnership
HQ	Headquarters
ILO	International Labour Organisation
Km	kilometre
LCS	Low Cost Surfacing
LRD	Local Roads Division (DoR)
LRDM	Lao Road Design Manual
LSRSP	Lao-Swedish Road Sector Project
LTEC	Lao Transport Engineering Consultants
LVRR	Low Volume Rural Road
m	metre(s)
MPWT	Ministry of Public Works and Transport
mm	millimetre(s)
MERLIN	**M**achine for **E**valuating **R**oughness using **L**ow-cost **IN**strumentation
MPa	Mega Pascals
MoU	Memorandum of Understanding
NUoL	National University of Lao
OPWT	Office of Public Works and Transport (District Level)
ORN	Overseas Road Note
PAD	Personnel and Administration Division (DoR)
PCU	Passenger Car Unit
Pen Mac	Penetration Macadam

PTD	Planning and Technical Division (DoR)
QA	Quality Assurance
Ref.	Reference
RRGAP	Rural Road Gravel Assessment Programme (Vietnam)
RRSR	Rural Road Surfacing Research (Vietnam)
RRST	Rural Road Surfacing Trials (Vietnam)
SCC	SEACAP Coordinating Committee
SEACAP	South East Asia Community Access Programme
SIDA	Swedish International Development Cooperation Agency
SOE	State Owned Enterprise
SPM	SEACAP Practitioners Meeting
ToR	Terms of Reference
TRL	Transport Research Laboratory
UK	United Kingdom
UNOPS	United Nations Office for Project Services
VN	Vietnam
VOCs	Vehicle Operating Costs
VPD	Vehicles per day
WBM	Water Bound Macadam
WLAC	Whole Life Asset Costs
WLC	Whole Life Costs

1 Introduction

1.1 SEACAP 3.02 and SEACAP 31

Although SEACAP 3.02 and SEACAP 31 were procured under separate contractual processes they are very closely interlinked in terms of technical content and intended output. The principal SEACAP 3.02 output was stated as being a practical manual based on the new LVRR Standards and Specifications whilst SEACAP 31 was concerned with the field trialling of the concepts in these same documents.

Following discussion with SEACAP it was proposed and agreed that the two projects would be run closely together from a technical viewpoint, whilst at the same time retaining their separate contractual and budgetary identities.

1.2 The overall SEACAP Context

The SEACAP 3.02 and 31 projects are part of the wider South East Asia Community Access Programme (SEACAP), whose strategic theme is 'livelihoods of poor and vulnerable people in SE Asia - improved sustainability'. The core SEACAP concept relevant to infrastructure was defined at the SEACAP Practitioners Meeting (SPM) in Phnom Penh in June 2006 as "maximizing input of local resources; which are materials, labour, enterprise and ingenuity which ensures affordability".

SEACAP builds on existing knowledge, but also provides a research resource for filling gaps in knowledge, particularly in the local environment. Mainstreaming ensures that these solutions are accepted, adopted and applied on a large scale. This involves a process of dissemination through participatory workshops, guideline documents, demonstrations, training and implementation.

SEACAP 3.02 and SEACAP 31 contribute to this overall objective through the practical demonstration and mainstreaming of local resource-based standards for low volume rural roads. This will allow more efficient and optimal use of the limited financial and physical resources available for the sector in Lao PDR.

1.3 Report Objectives

The aim of this report is to present a concise summary of the combined SEACAP 3.02 and SEACAP 31 projects.

In particular, this report highlights the following:

- The work undertaken in relation to the stated objectives
- Key outcomes from the combined technical programme
- Recommendations on the way forward

2 Project Framework

2.1 Project Objectives

The SEACAP 3.01 Contract Report made recommendations with respect to the mainstreaming of the main documents and suggested that they *"…should be trialled on an appropriate rural road to provide both a research base for their possible enhancement and to provide a demonstration of the benefits from environmentally optimizing the design approach to rural roads."*

SEACAP 3.02-31 was therefore a response to an identified need to enhance the impact of important practical research and its associated documentation. Key activities were defined in the ToR as being:

SEACAP 3.02:

- Review of relevant documents
- EOD Manual: drafting and translating
- Field testing of the EOD Manual
- Training and dissemination associated with the EOD Manual

SEACAP 31:

- Review of relevant documents
- Identify five critical sections on an identified trial road
- Collect the data for the spot improvement of these five sections
- Design the paving and surfacing options to be trialed
- Provide supervision and data collection training
- Provide on-site advice to the supervising engineers
- Carry out an as-built survey of the trials.

A existing 52 km track in Phongsali Province linking National Road 1B at Ban Phicheumai and the Nam (River) Ou at Samphan District Centre was being upgraded to provide all-year vehicular access at the time of project definition and this was identified as being the designated "trial road". The capital works were being largely funded by SIDA through the LSRSP III, with SweRoad as principal consultants. It was agreed that DfID, through SEACAP, would contribute an additional £50,000 for the construction of a number of short pavement trial sections as the SEACAP 31 field testing area.

During the inception phase the key activities from the combined SEACAP 3.02-31 programme were identified and programmed within a number of Task Groups, Figure 1.

2.2 *Contractual Arrangements*

In response to Requests for Proposals from Crown Agents for Overseas Governments and Administrations Ltd (acting as Contracting Agent for DfID), TRL provided comprehensive technical and financial proposals for carrying out the projects and subsequently entered into a contractual arrangement with Crown Agents for both SEACAP 3.02 and SEACAP 31.

TRL is supported in its undertaking of the two projects by associate firms. The principal associate firm is a State Owned Enterprise, Lao Transport Engineering Consultants (LTEC), who are providing comprehensive local consulting services, including administrative support. The other associate firm is OtB Engineering (International) Ltd, consulting engineers, who provide the services of Dr J Cook as Team Leader.

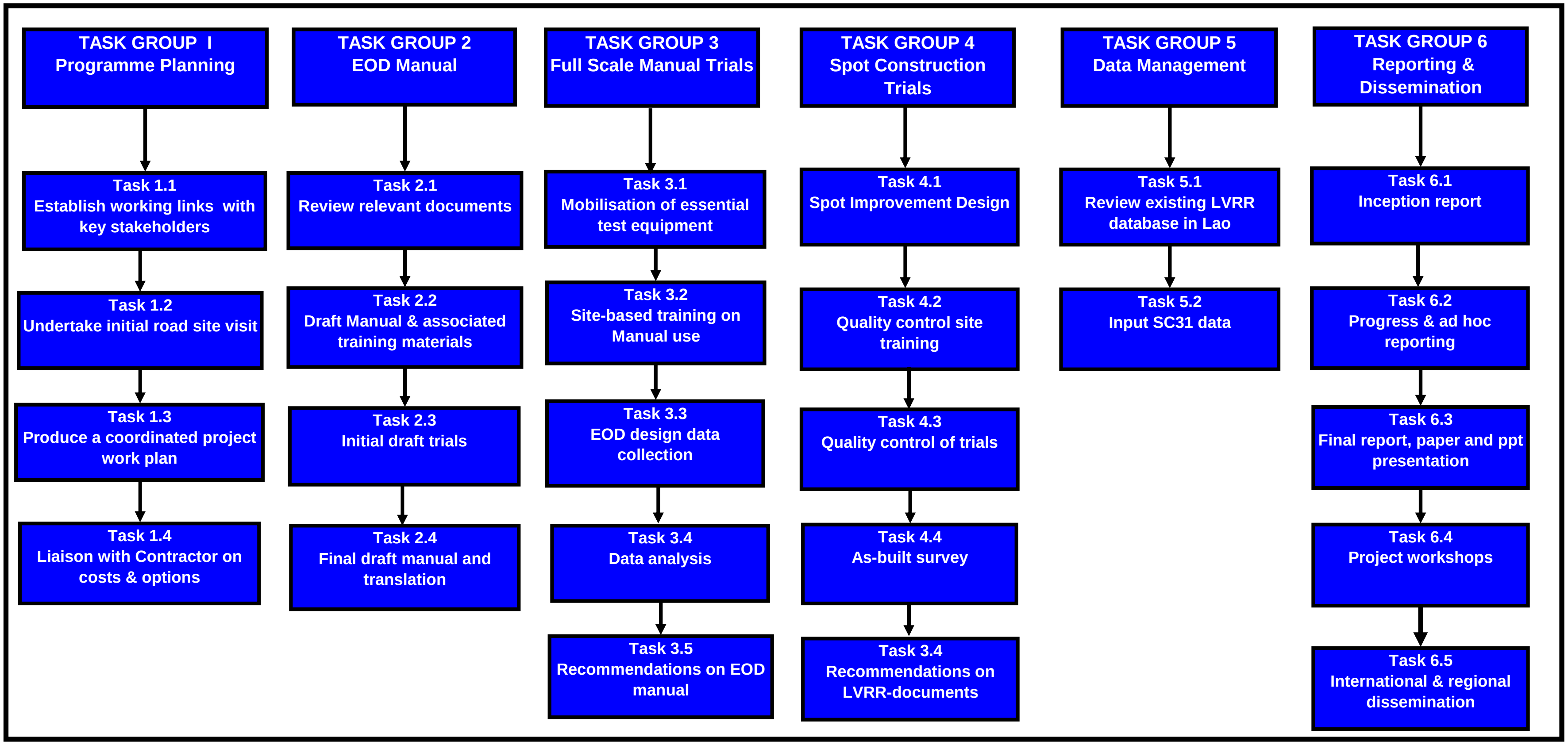


Figure 1 Task Groups for SEACAP 3.02 and SEACAP 31

2.3 *Mobilisation*

The joint programme was effectively initiated on June 22nd 2008 with a preliminary site visit by Dr J Cook to Samphan Road in conjunction with SEACAP and SweRoad. Subsequently the SEACAP 3 office at LTEC was re-mobilised on 24th June with telephone and internet communications. Simon Done was mobilised from the UK on 15th July.

2.4 Project Relationships

It was essential that SEACAP 3.02-31 continued the close working relationships developed during SEACAP 3.01 with the MPWT and in particular the Local Roads Division within the Department of Roads.

2.5 *Project Staff*

The team assembled to undertake the identified project tasks was largely based on the core team that successfully completed the SEACAP 3.01 programme with the exception of Mick O'Connell whose work was split between Dr Cook and Simon Done. Table 1 lists the SEACAP 3.02-31 core team as mobilised, together with their key responsibilities.

Table 1 Core Team Responsibilities

Name	**Responsibilities**
Dr J R Cook	Team Leader. Programme management, technical reporting, trials design and supervision support.
S Done	Senior Researcher. Drafting the EOD manual and training materials. On site training. Reporting.
Bounta Meksavanh	Local Team Leader. Programme management and engineering advice.
Saysongkham Manodham	Senior Road Engineer – Site supervision support and as-built survey. On site training.

In addition, Dr John Rolt and Akram Ahmedi were identified as support to the core team for Quality Assurance and overall management.

3 Task Group 1: Programme Planning

3.1 Requirement

Key tasks within this Group were identified as follows:

1. Establish working links with key stakeholders:
2. Undertake an initial road site visit.
3. Produce a coordinated project work plan; this forms a key part of this Inception Report.
4. Liaison with the contractor on costs and options.

3.2 Work Completed

The fundamental elements of the SEACAP 3.01 working relationships were carried through to SEACAP 3.02 and SEACAP 31. Crucial elements were:

1. The SEACAP Coordination Committee (SCC) coordinated project strategy and progress in conjunction with SEACAP
2. Operational links were coordinated through the LRD

Two key stakeholders were identified outside the MPWT at project inception namely:

1. The LSRSP-III programme who were funding the Samphan Road construction. Strong cooperation links were established through Per-Olof Lovmar, Team Leader, LSRSP III.
2. National University of Lao (NUoL), through Professor Nhinxay Visane (Department of Civil Engineering).

A site visit was undertaken to Samphan Road, Figure 2, from the 24^{th} to 26^{th} of June and reported as part of the Inception Report. It was concluded from this site visit that Samphan Road was a suitable trial site although it was seen as practical that the work should be limited to the first 10 km of the road. Initial contacts were made with the contractor during this visit.

A combined SEACAP 3.02-31 work plan was drawn up and included within the joint Inception Report.

Figure 02 Location Map of Material Sources in Ponsali Province, LAO PDR

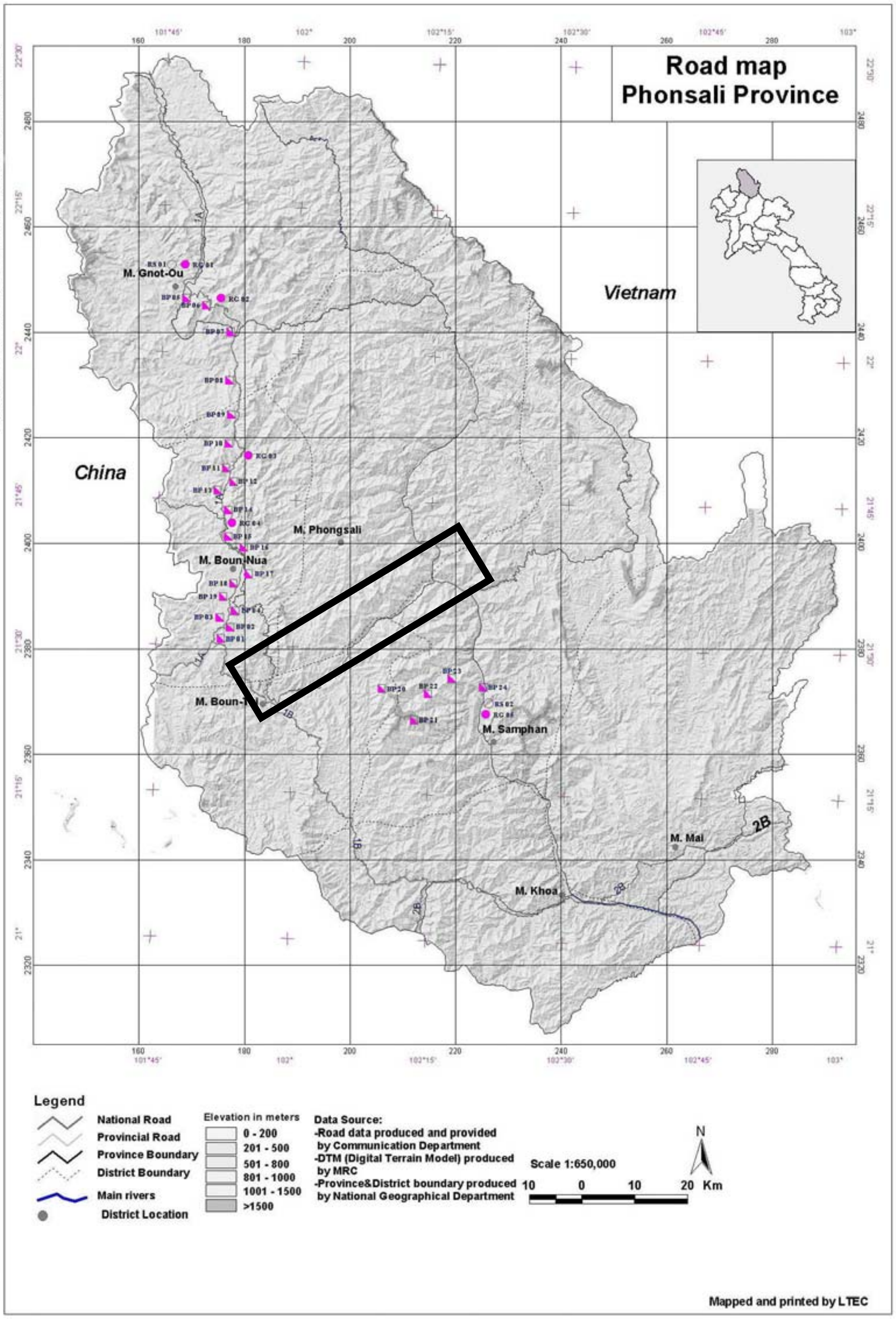


Figure 2 Location of Samphan Road

4 Task Group 2: The EOD Manual

4.1 *Requirement*

The key requirement was a concise practical manual focusing on the engineering aspects of applying EOD at sub-province level. This should be designed to include the existing recommendations and advice contained within the LVRR Standards and Specifications Parts I, II and III. The draft document, prepared in English, will be translated into Lao.

The draft manual was required to be trialled on site under normal working conditions.

4.2 Work completed

The first draft of the EOD manual was completed between July and September 2008 following a review of the LVRR Standards and Specifications and an initial site trial of preliminary concepts. A preliminary draft version was presented to a project Progress Meeting on the 14th of August.

The completed first draft was then trialled on Samphan Road in northern Lao in September and November 2008 and some amendments incorporated in the Final Draft version. The draft was then submitted to LRD and other key stakeholders in September for comment and approval.

The Manual then went through a final phase of amendments and Quality Assurance editing, before the Final Version was submitted in March 2009.

4.3 Key aspects of the Manual

The core of the manual is a sequence of data collection, decision making and design steps, from initial decisions regarding the viability of the project to collation of documents necessary for the construction contract.

Since the manual will be mostly used on roads which have gradually developed from paths to unformed tracks or roads which have then fallen into poor condition, the sequence of steps is focussed on the improvement of existing routes, although this is followed by notes on how each step may be amended if a new road is to be constructed along a new alignment.

The manual emphasises the following EOD principles:

- The design of each section of a road must suit the local conditions: gradient, material availability, flood risk, etc.
- Since some conditions vary along the length of a road, the design of the road may also vary along its length.
- It may be appropriate to use restricted funds to improve sections of road in poor condition, while leaving others, that are likely to remain passable under expected traffic, unimproved until more funding becomes available.

The manual has a clear structure and logical sequence and is appropriately illustrated with flowcharts, photographs, figures and tables. The data collection, decision making and design sequence for the improvement of an existing route has the following steps.

> **Screening:** This step is used to prevent effort being wasted on unviable proposals for which construction or maintenance resources are clearly inadequate. It will also redirect users to the Lao Road Design Manual (LRDM) if expected traffic levels are higher than those for which the LVRR Standards and Specifications are applicable.
>
> **Rapid Survey:** This describes appropriate procedures for an initial visit to a site to gain an overall understanding of the nature of the road, the typical problems and likely solutions before detailed survey and design work begins.

Assessments: A series of assessments are then described which provide information for later pavement selection and design decisions.

Initial design work: The basic road geometry can then be designed using collected information on vehicle type, traffic volume, terrain and other key road environment factors.

Main survey: The survey procedure is described involving the use of a Main Survey Form. Advice is included on the composition of the survey team, the equipment required, identifying uniform sections, items to be recorded and priority criteria by which each section will be prioritised for improvement.

Data collection: This section describes the use of the Dynamic Cone Penetrometer (DCP) and laboratory tests to estimate the subgrade strength and the range of tests which might be required to assess nearby material sources.

Selection of improvements: This includes guidance on a wide variety of improvements that may be appropriate for different defects and situations. This section links each record on the Main Survey Form to one or more suggested improvements. The user of the manual can then choose the improvement that is most appropriate for the specific conditions at the site.

Pavement and surface design: This section provides a series of tables which are used to select the most suitable pavement and surface type according to available materials, maintenance regime, gradient and rainfall. Once the type or types have been selected, the user of the manual is then referred to the relevant design guidance in the Appendices.

Estimation of costs: This section provides guidance on estimating the costs over the design life of the work – the ‘whole life asset costs’ – with future costs discounted according to the appropriate discount rate.

Prioritisation: When funds are restricted, it may not be possible to construct all the improvements selected for a road. It is necessary to select them according to their importance or priority. Prioritisation guidance is provided to select improvements according to their priority criteria. A table also lists a number of very low cost activities which can be carried out to reduce the deterioration rates of sections which have not been selected.

Contract documents: This section very briefly lists the information which should be included in contract documentation.

Appendices: A series of Appendices are provided which provide more guidance on key aspects of the selection and design procedures as well as safety measures and slope stabilisation (with reference to SEACAP 21 work in Lao). The Appendices end with a series of exercises and examples, guiding the user of the manual in traffic analysis, subgrade analysis, pavement design and whole life asset cost estimation. However, the main element of the appendices is a set of design charts for each pavement and surface type: gravel; sealed gravel and sealed macadam; sealed armoured gravel; and unreinforced concrete.

5 Task Group 3: EOD Field Trials

5.1 Requirement and Objectives

The ToR relating to Task Group 3 stated that 'in cooperation with the appropriate authorities and project personnel, the consultants should carry out the EOD design of a selected road, to field test the draft manual'.

Key aspects for the successful implementation of Task Group 3 were identified as being

1. The involvement of engineers from LRD, the Province and the District. It would also be desirable for a team from the National University of Lao (NUoL) to take part in this trial, bearing in mind their commitment to their new Rural Engineering Modules.
2. On site training of an identified group of engineers drawn from Phongsali Province and adjacent provinces. This training will include hands-on guidance on in situ testing and walkover road assessment procedures as well the consequent analysis of recovered data.
3. Deficiencies or other problems with the Manual, identified during the field trial, would be discussed with potential users and suitable amendments made.

The first objective of this work was to trial the LVRR Standards and Specifications and the draft EOD Manual by designing improvements for the first part of Samphan Road. The second objective was to use the trial to train Provincial, District and other staff in the Standards, Specifications and Manual.

5.2 Work Undertaken

In addition to the initial inception visit in June 2008 three further site visits were made to the Samphan site in August, September and November. Summaries of these visits and their achievements are given below. Full details are included the relevant Project Progress Reports.

24-26th August: This visit addressed the logistics and timing of the trials and identified the participants that would be invited to attend.

6th – 11th September. A total of 15 participants from DPWT Phongsali, District OPWT offices, LRD, NUoL, LTEC, the contractor working on the road and the LSRSP site supervisor attended this first trials and training week. Saysongkham Manodham of LTEC and Simon Done of TRL supervised the trial work and the associated training. Key activities were:

- The draft EOD Manual, which had been part-translated into Lao, was handed out to participants and the content introduced step by step. The exercises in the manual were carried out by participants working in groups.
- Five groups each made a survey of the first 10 kilometres of the road using the Main Survey Form, selected sections to be improved and started outlining the design of the improvements.
- Presentations were made by each group of their survey and designs, accompanied by a strip map showing the sections to be improved.
- The group work was summarised into an agreed series of sections to be improved, totalling approximately 6 kilometres of the first 10 kilometres, based mainly on gradient or the presence of villages.

23rd-27th November. A similar group of participants to those at the first week attended, although a few had not been at the first week. A handout, prepared for the workshop and explaining the background to EOD, the Standards and Specifications, the design method and example design charts, was described in detail. The main objective of this week was to confirm the selection of the spot improvement sites and to gather relevant pavement design information for these locations, with a focus on the first 5 km of the road. Key activities and outcomes from the field work and subsequent discussions were:

- Gradients of spot improvement sites selected during the first week were cross-checked using an Abney hand level
- DCP tests were undertaken on the selected spot improvement sites.
- DCP data was analysed and gradient data was used to confirm the sections for spot improvement, Table 2.
- Subgrade design strengths were estimated from the DCP results and initial pavement designs were proposed after making reasonable assumptions about the expected traffic level.
- Subgrade samples were taken for laboratory testing from along the proposed trial sections.
- It was decided that sections should be prioritised in order from the start of the road.
- A number of suggestions to improve the EOD manual were made by the participants.

Table 2 Sections Recommended for Spot Improvement Trials

Section	Chainage	Length (m)	Cumulative length (m)	Reason
1	0+000 – 0+360*	360	360	Phicheumai
2	1+200 – 1+865	665	1025	6% or steeper, apart from 1 short length
3	1+950 – 2+100	150	1175	6% or steeper, including a sharp curve
4	2+400 – 2+520	120	1295	6% or steeper
5	2+750 – 3+350	600	1895	6% or steeper, apart from 3 short lengths
6	3+800 – 4+200	400	2295	Phicheukao
	4+200 – 4+530	330	2625	6% or steeper

Length later adjusted to 0+000 - 0+335

The pavement options to be used in the detailed design of the spot improvements were identified as:

- Unreinforced concrete
- Sealed natural gravel
- Sealed armoured gravel

The use of sealed dry-bound macadam was considered but was rejected because of the lack of suitable local construction materials.

5.3 Key Issues arising out of Site Discussions

A number of important issues relating to the use of the Standards, Specifications and EOD Manual arose during the Samphan trials.

Priority criteria: Although poor condition is likely to be a significant priority criterion for many roads on which the EOD Manual is used, this is clearly not the case for a road which is being provided with a new gravel wearing course under an ongoing contract. For Samphan Road, the sections likely to deteriorate most quickly are those on a steep gradient and this and the presence of a village were the key selection criteria. During the workshops, 6% was used when selecting steep sections for improvement. Other criteria such as unstable slopes may yet prove to be relevant after the road has experienced a rainy season, but at this stage, with no sign of major deterioration, it was not yet relevant.

Uniform sectioning: The EOD survey and design method is based upon the identification of sections which are reasonably uniform in aspects such as village, gradient, flood risk and overall condition. In discussion at the end of the second week, one of the suggestions for the manual was to retain the identification of uniform sections but to also allow the road to be surveyed at a regular spacing, typically 50 metres. In general, therefore, the principle of uniform sections was accepted and used.

Traffic restrictions: During discussion of traffic along Samphan Road, the possibility of large vehicles using the road was mentioned. Since the Standards and Specifications are based upon a maximum axle load of 4.5 tonnes, it is necessary to ensure that very low numbers of heavy trucks use the road. Senior staff from DPWT Phongsali stated that it is accepted that they should enforce some restriction along Samphan Road using, for example, closely spaced concrete posts, although such measures had not yet been enacted by the time the construction of the road was being completed.

Determining subgrade design strengths: It is important that the assessed subgrade strength correctly anticipates the minimum strength of the subgrade during the year since this strength can significantly drop when the subgrade becomes saturated in the rainy season.

Determining gradient: It is important to be able to estimate or measure gradient reasonably accurately. It is recommended that suitable simple instruments are used to measure gradient rather than by estimating the gradient visually. A hand level appears to be the most appropriate instrument, although it can be rather slow to use during a survey, and a GPS, if used carefully, can be useful in hilly terrain.

Appropriate equipment: The workshops included training in the use of a DCP and a hand level. These two items proved to be easy to learn to use and understand and reasonably quick at data collection. It is recommended that they are seen, wherever possible, as equipment suitable for a survey and, again wherever possible, made available to Provincial and District staff.

6 Task Group 4: Spot Improvement Construction Trials

6.1 Requirement

The ToR required that necessary data be collected for the design of appropriate pavement and surfacing options on critical sections along Samphan Road. The design of the trial sections was to be based on the procedures contained in the LVRR Standards and Specification documents. The actual construction cost of these trials was to be within the lump sum of £50,000 set aside for this purpose by DfID.

An as-built survey of pavement condition should be undertaken on the completion of the trials construction.

6.2 Spot Improvement Pavement Designs and Costs

The data gathered and analysed as part of the EOD Manual trial process (Task Group 3) was used as the basis for the Spot Improvement pavement designs. The design process is described fully in Progress Report 2, but in summary comprised the following key elements:

1. Assessment of subgrade condition based on a combination of in situ DCP testing and laboratory soaked CBR values, Table 3.

2. An assumption that traffic should be Group B – as defined in the LVRR Standards and Specifications.

3. The newly constructed wearing course on the Samphan Road of 150 mm of natural gravel was incorporated into the trial designs either as a sub-base or capping layer, depending on the strength of the underlying subgrade.

4. The pavement thicknesses would be designed based on the relevant design charts within the EOD Manual (as derived from the LVRR Standards and Specifications).

Table 3 Selected CBR Values for Trials Pavement Design

Section	Chainage	Selected CBR Value (%)
S1	0.000-0.335	2-6.9
S2.1	1.200-1.400	7-10.9
S2.2	1.400-1.700	>11
S2.3	1.700-1.865	7-10.9
S3.1	1.950-2.025	4-6.9
S3.2	2.025-2.100	>11
S4	2.400-2.520	4-6.9

The pavement designs to be constructed as EOD Spot Trials are summarised in Table 4; further details are contained in Appendix A.

Table 4 Spot Improvement Trials Design

Ref.	Option	From-To	Spot Improvement Design	Use of Existing Gravel (150mm of Gravel III)
S1	Non Reinforced Concrete	0.000-0.335	150mm concrete	Sub-base
S2.1	Sealed gravel	1.200-1.400	DBST 100mm base – gravel I 75 mm sub-base – gravel III	Capping layer
S2.2	Sealed gravel	1.400-1.700	DBST 100mm base –gravel I	Sub-base
S2.3	Sealed armoured Gravel	1.700-1.865	DBST 70mm CSA 100mm base – gravel III 75 mm sub-base –gravel III	Capping layer
S3.1	Sealed gravel	1.950-2.025	DBST 100mm base-gravel I 125mm sub-base – gravel III	Capping layer
S3.2	Sealed gravel	2.025-2.100	DBST 100mm base – gravel I	Sub-base
S4	Sealed armoured gravel	2.400-2.520	DBST 70mm CSA 100mm base – gravel III 125mm sub-base –gravel III	Capping layer

Notes: Gravel I = CBR 80%: Gravel II = CBR 50%; Gravel III = CBR25% Soaked @95% Mod MDD

The costs for the Spot Improvement trial sections were originally based on figures discussed with both LRD and the Contractor during November and December 2008, Table 5. TRL-OtB had noted that they considered some of these costs to be above what might be expected, even accounting for an increase because of the restricted nature of the trial. The detailed costs based on these figures are included within Appendix A.

Table 5 Pavement Construction Costs

		Contractor Proposal		Agreed November 2008	
	Unit	Cost (kip)	Cost US$	Kip	US$
Seal (DBST/Double OTTA)	m2	95,000	10.97	70,000	8.08
Capping Layer	m3	90,000	10.39	25,000	2.89
Gravel Wearing Course (Gravel III)	m3	250,000	28.87	50,000	5.77
Gravel II	m3	480,000	55.43	180,000	20.79
Gravel I	m3	500,000	57.74	200,000	23.09
Crushed Stone Agg (CSA)	m3	550,000	63.51	400,000	46.19
Non Reinforced Concrete	m3	2,500,000	288.68	1,750,000	202.08
Existing contract Gravel	**m3**	**50,000**	**5.77**		

6.3 Trials Construction – Contractual Issues

The Spot Improvement trials were designed in November 2008 and due for construction later that year and in the first months of 2009. There were however, significant delays in obtaining a clear commitment from the Contractor and eventually his final construction rates were significantly higher than previously discussed. These higher than agreed construction costs combined with the low Sterling to US Dollar exchange rate at that time meant that only about 600 metres of trial could be built within the DfID budget of £50,000.

In discussion with LRD the SEACAP management decided that the best course of action would be to postpone the trials construction until a next phase of funding became available. The principal reasons for this cancellation were noted in a SEACAP (Mr David Salter 18.02.09) communication to LRD as:

> "*…..costs are overall 30% higher that what we understood were agreed to after last months negotiations. The costs that we had agreed upon gave an overall cost of USD 95,145. This already included several items that we felt were highly priced. The total cost now comes to USD 123,286. A total increase of USD 28,142.*
>
> *The costs are particularly high and without an obvious reason for DBST. For standard gravel we notice that we are being asked to pay 300% more than what is the unit rate in the SIDA project*.
>
> *Clearly DFID/SEACAP cannot accept these costs and before proceeding would need to re-enter negotiations to obtain more reasonable prices. Given the delays in getting to this point and the constrained time left in the current phase of SEACAP, I do not see how we can proceed with these trials. We do not have time now to enter into new negotiations*.

TRL-OtB supported this decision not only for the reasons stated above but also in that a Spot Improvement trial constructed after at least one rainy season would have much more scientific validity that one completed whilst main construction was still being undertaken.

The contractual arrangements for the supervision of the construction by SEACAP 31 were then amended to include additional survey work of the as-built gravel wearing course and training of Provincial staff, to be carried out over a week in early May 2009. This work is described in the following Chapter.

7 Revised Samphan Road Data Collection Programme

7.1 Scope of Work

The following sections summarise the work carried out during May 2009 and the subsequent analysis and discussion. More detail is provided in Appendix B.

The objectives of this amended programme were to:

- Carry out a detailed survey of the as-built gravel wearing course construction of the 4 proposed trial sections in the first 2.5 kilometres of the road and compare the results with both the specifications for that work and the assumptions made when designing the improvements to those sections.

- Undertake a related gravel assessment spot survey.

- Carry out a rapid condition survey of the remainder of the road to record the overall nature of the road, identify problems along the road and suggest possible solutions.

- Further train provincial, district and other staff in site procedures.

This work was carried out in a single visit from the 2nd to the 9th of May. Ten participants from the Province attended, most of whom had attended one or both workshop weeks in 2008. Four days were spent on site carrying out the detailed surveys, based on methods previously used on SEACAP projects in Vietnam, Cambodia and elsewhere in Lao. The surveys were carried out by combined SEACAP and Phongsali teams. A traffic count was planned but was not carried out since traffic levels were so low. The extent and nature of the work is illustrated in Figure 3.

Samples of gravel were taken from ten locations along the trial sections and four gravel sources along the entire road. Site records, made during construction, were requested and sent from Phongsali to Vientiane shortly after the survey work.

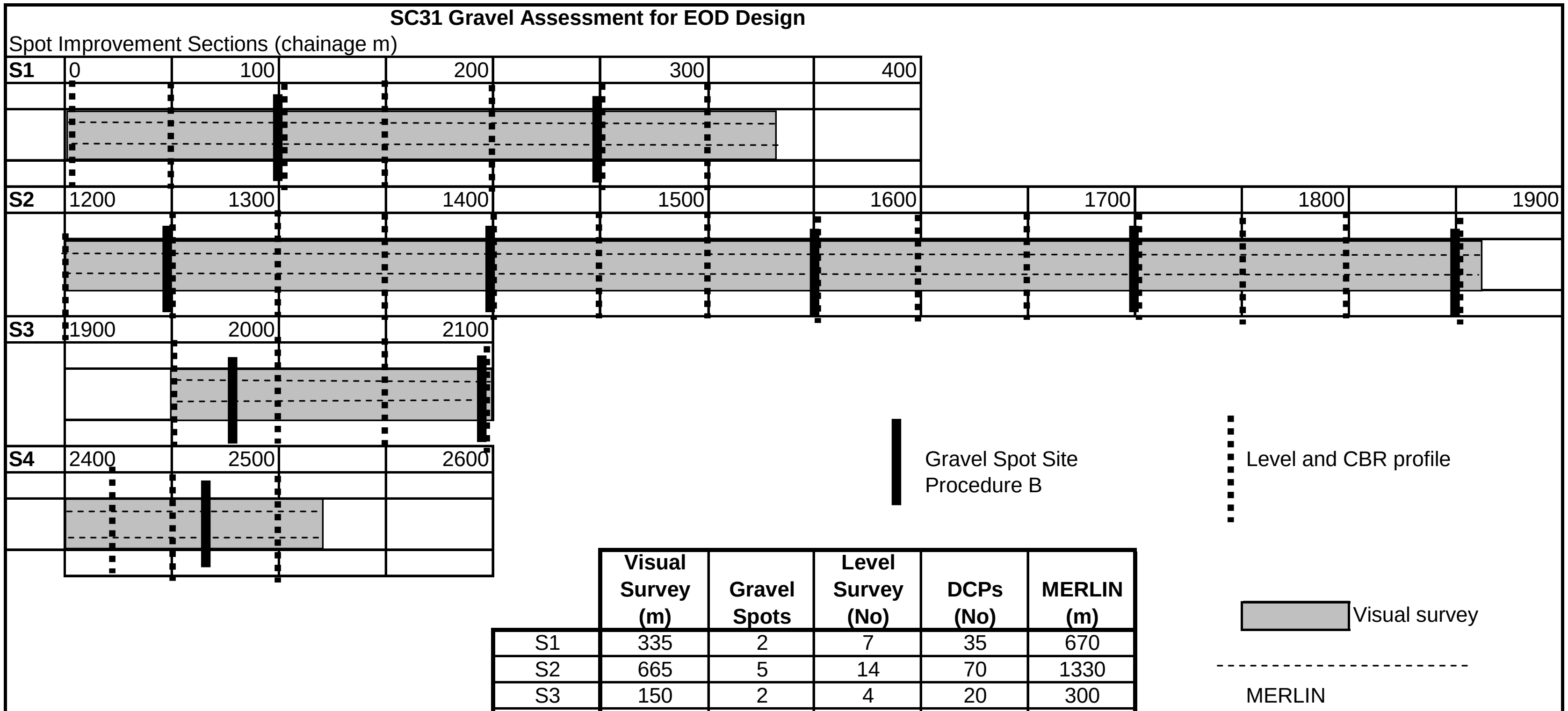
7.2 Trial Section Condition Survey

The survey work comprised the following:

1. DCP cross-sections carried out on the centre line, in both wheeltracks and at the shoulders at a spacing of 50 metres along all 4 trial sections; giving a total of 140 tests.

2. The roughness of each wheeltrack along all 4 trial sections was measured in 100 metre lengths using the MERLIN equipment.

3. An automatic level, staff and tripod were used to accurately measure the cross section profiles, including the cambers, of the road with one point on the centreline and 4 points at 500 mm spacing on either side. Cross sections were measured at a spacing of 50 metres along all 4 trial sections, giving a total of 29 cross sections. The levels were referenced to TBMs installed alongside the road.



	Visual Survey (m)	Gravel Spots	Level Survey (No)	DCPs (No)	MERLIN (m)
S1	335	2	7	35	670
S2	665	5	14	70	1330
S3	150	2	4	20	300
S4	120	1	3	15	240
Total	**1270**	**10**	**28**	**140**	**2540**

Figure 3 Extent and Nature of As-Built GWC Surveys

4. A detailed visual survey of the carriageway, shoulders and side drains of all 4 trial sections was made by dividing the road surface into 5 metre blocks and then assessing aspects such as loose material, rutting, erosion and potholes using defined codes for differing degrees of damage and extent.

7.3 Gravel Assessment Spot Survey

A gravel spot survey was made by assessing a number of single 10 metre blocks using survey procedures developed for the SEACAP 4 project and subsequently modified for use on SEACAP 19 and SEACAP 17.02. For each block a variety of assessments such as width, erosion, camber, gradient, drainage condition and gravel thickness were made, using defined codes. A total of 10 gravel spot surveys were carried out on the trial sections.

7.4 Rapid Condition Surveys

A variety of rapid surveys were carried out, each survey recording different levels of detail of the road and having different rates of progress along the road. A number of conclusions regarding rapid condition survey methodologies is given in Appendix B, an important one being that each survey must be matched to its specific needs and the available resources.

Conclusions from the rapid surveys are summarised as follows:

Spot Improvement: Sections beyond the first 5 kilometres were identified where further EOD surveys should focus. These are listed below in Table 6:

Table 6 Additional Spot Improvement Areas

Reference	Chainage: From-To
1	5+750 – 7+000
2	7+500 – 7+800
3	8+250 – 8+800
4	9+200 – 10+700
5	13+750 – 14+500
6	20+500 – 22+400
7	24+500 – 30+500
8	31+000 – 32+500
9	33+300 – end of road

Traffic: Low levels of traffic were using the road, but it is very likely that these will increase rapidly.

Gravel: Many shoulders along the road appear poorly compacted and loose and hence likely to deteriorate rapidly and impact on the width of the carriageway.

Slope Conditions: The slopes above and below the road along most of the road are likely to deteriorate and the planting of vegetation should be undertaken to stabilise the slopes.

Longitudinal erosion: The camber of the gravel surface is often inadequate. On level sections this can allow ruts and potholes to develop, but the deterioration caused by longitudinal erosion in the wheeltracks down slopes can be much more rapid. Erosion has already begun on some steep sections and is likely to get much worse. It is likely that this will the primary cause of any loss of access.

Steep Terrain: Almost half the length of the road has a gradient of 6% or more, the gradient at which the Standards and Specifications recommend that gravel is improved with a non-erodible surface in areas with rainfall similar to that along Samphan Road. Complete improvement of Samphan Road is likely to therefore be very costly.

Drainage: Two of the most significant problems are the long lengths of side drain without the means to dispose of the water, either along mitre drains or through culverts, and the poor construction of culvert inlet and outlet structures and outfall channels. Many of the inlet and outlet structures have headwalls and wingwalls that are too low and liable to attract severe erosion by water flowing off the carriageway. Many outfall channels appear poorly located and protected against collapse and erosion.

7.5 Analysis

After return to Vientiane the survey data was analysed along with results from the fourteen gravel samples and the available site construction records. The results were used to compare completed work with the contract specifications and the assumptions behind the improvement designs. The results of this analysis are summarised as follows:

Gravel Wearing Course

In most places the gravel layer is less than 150 mm thick. The roughness of the surface is within typical limits for a newly constructed gravel road. However, the camber is inadequate and is likely to contribute to rapid deterioration of the gravel surface, particularly on steep hills. Minor longitudinal erosion in the wheeltracks was observed even before the 2009 rains had properly begun.

The width of the gravel carriageway is generally adequate but is likely to reduce rapidly as the segregated and poorly compacted shoulders deteriorate.

The gravel wearing course has a DCP-CBR strength of around 25%, A limited number of density tests, supported by site observation, indicate that the gravel has been adequately compacted. The combination of density tests with the DCP-CBR values indicates a generally adequate strength for the wearing course. The strength of the gravel, probably due to additional compaction during construction and from subsequent traffic, is higher along the centre line of the road and in the wheeltracks than on the shoulders.

However, the quality of the gravel, as indicated by the grading and plasticity of the samples, is poor, with most samples failing one or more criteria. There is considerable variation between tests in 2008 and 2009 from the same source.

Subgrade

Subgrade strengths are generally significantly higher than those assessed during the design of the improvements. In some locations the strength of the subgrade under the outer shoulder is lower than under the centre line or the inner shoulder, possibly indicating weakness due to proximity to a loose down slope, although the strengths are still above the specified minimum and the design assumption.

7.6 Training

During the first four days of the site work, the SEACAP team trained Phongsali staff in the different detailed survey methods that were used. On the final day, Phongsali staff trained LTEC staff in the EOD survey methods used during the first workshop week in 2008. The training on both sides was effective and all participants were pleased to have learned new survey and analysis techniques.

8 Task Group 5: Data Management

8.1 Requirement

The original ToR envisaged that all the data collected in relation to the SEACAP 31 trials design, construction and as-built survey would be incorporated into the LVRR database established as part of SEACAP 17.

In the event this course of action was not followed for two main reasons:

1. The nature and structure of the existing SEACAP 17 database are incompatible with the data sets collected for the trials design and the as-built gravel wearing course surveys.

2. The data collected as part of the gravel spot survey was also incompatible with the existing SEACAP 17 database structure.

8.2 Work Completed

The trial section condition survey data and the gravel spot survey data have been collated, QA cross-checked and stored in .xls file format. This data together with EOD Manual trials information is currently held on the LTEC main server in Vientiane.

9 Task Group 6: Reporting and Dissemination

9.1 Reporting Work Completed

The following report and technical documents have been produced by the combined SEACAP 3.02-31 programme:

Inception Report	August 2008
First Progress Report	September 2008
Second Progress Report	December 2008
Third Progress Report	March 2009
EOD Manual	April 2009
Fourth Progress Report	May 2009
Final Report	June 2009
Technical paper	June 2009

9.2 Dissemination and Training

There have been three principal training events organised as part of SEACAP 3.02-31. The focus has been on site work, supplemented where appropriate with classroom instruction and group presentations. When on site, participants have been encouraged, after initial direct instruction, to learn by carrying out surveys and tests. Most of the data used in the assessment of the completed gravel road and the design of the improvements has been collected by groups staffed fully or partly by those under training and learning how to carry out the surveys.

The intention has always been for the same Phongsali staff to attend all training events so that those staff become fully skilled in the methods and analysis.

Prior to the EOD trials, attempts were made to include technical staff from Oudomxay Province and other nearby Provinces. Unfortunately this did not prove possible, but the places on the workshop were allocated instead to include more District based staff from Phongsali Province than was previously intended.

Both workshop weeks during the EOD trials were attended by a member of teaching staff from the NUoL, although for logistical reasons it was not possible for the same person to attend both weeks. The intention of LRD and MPWT is that the Standards, Specifications and the EOD Manual should become part of the NUoL curriculum.

9.3 Workshops

The following workshops and progress meeting have been held with respect to the combined SEACAP 3.02-31 project:

Progress meeting:	14th August: (Draft Manual) 2008
Site workshop 1	On site 6th to 11th September 2008
Site workshop 2	On site 24th to 27th November 2008
Site workshop 3	On site 4th to 8th May 2009
Final Workshop	17th June 2009

10 Conclusions and Recommendations

10.1 Outcomes

The combined SEACAP 3.02-31 programme was completed within the period June 2008 to June 2009 as indicated on Figure 4.

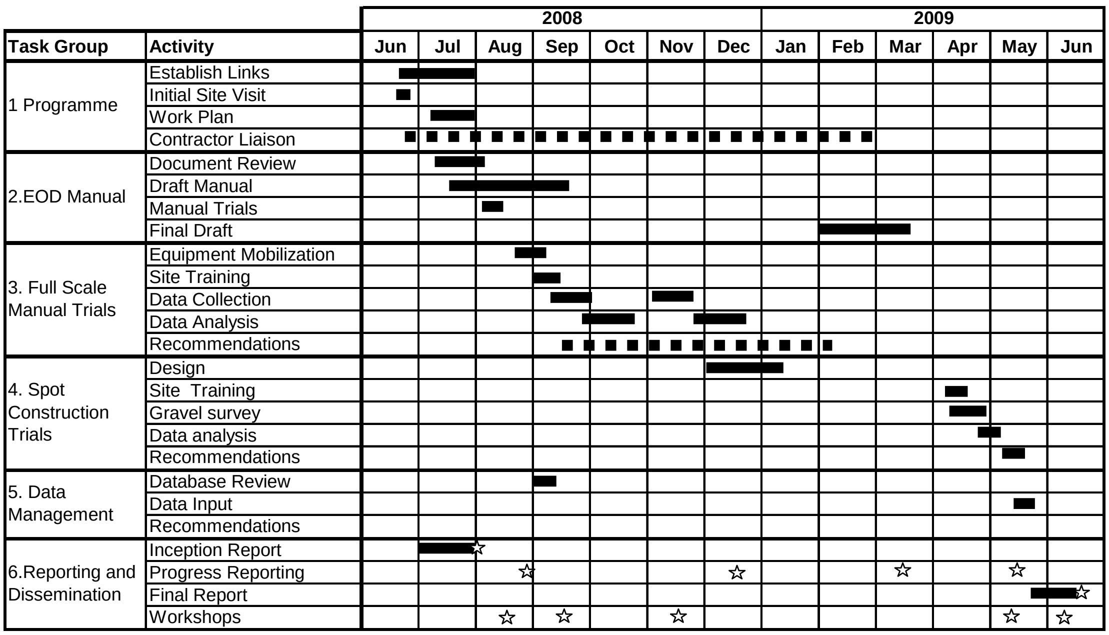


Figure 4 SEACAP 3.02-31 Programme

The completion of the EOD Manual and its acceptance by LRD as a working document is a major success for SEACAP. Its effectiveness as a practical document was demonstrated by its use on site as a basis for the identification and design of Spot Improvement sections on Samphan Road.

Unfortunately, for reasons outside the control of SEACAP 31, the proposed Spot Improvement trials were not constructed. However the trial pavements have been designed and costed and remain ready for application if and when funding becomes available.

An as-built survey of the condition of the Samphan Road gravel wearing course has been completed and conclusions drawn with respect to compliance with contractual specification and the assumptions made for the purposes of trial design.

It is worth noting that during the inception phase a risk assessment was undertaken on the likely problems facing the SEACAP 3.02-31 programme. This assessment is updated in the light of actual events as Table 7.

10.2 Recommendations

The EOD Manual

The translated EOD Manual should be formally adopted as an MPWT document in conjunction with the LVRR Standards and Specifications. It is recommended that the EOD Manual be published in A5 format with laminated covers for durability and wire binding for ease of use on site. All the forms which are referred to in the Manual – traffic counting, traffic analysis and survey – are provided in A5 format and these should be expanded on a photocopier to be ready for use on site in A4 format.

Much of the EOD method is likely to be new to Provincial and District staff who will use the Manual. It is therefore essential that adequate training is provided at this level. This training should be site-based and involve the practical solution of real problems. The site exercise approach adopted during the DF 55 and DF 090.l02 programmes could serve as a model for this.

It is recommended that a well planned national programme of dissemination, training and demonstration trialling is undertaken in at least a third of all Provinces and that staff in neighbouring Provinces be invited to attend. This programme should also include a subsequent period of mentoring during which staff make regular visits to all Provinces to follow progress in learning and implementing the approach, methods and procedures.

Every effort should be made to encourage the involvement of NUoL in the dissemination, training and take-up of the EOD manual. The acceptance of the EOD principles within NUoL Rural Engineering Modules would be a major step forward in ensuring the future championing of this approach for the essential development of the Lao LVRR network.

The Samphan Road Trial Sections

When further finding becomes available the identified Spot Improvements should be constructed and monitored as a demonstration of the EOD principles and a trial of the LVRR Standards and Specification pavement design approach.

It is recommended that prior to construction the original sections be resurveyed as to gravel wearing course condition and the spot pavement designs modified in the light of any significant changes in design assumptions.

It is clear from the rapid survey undertaken along the length of the Samphan Road that significant further lengths of this road are at risk from erosion due to gravel surfacing on high gradients. The recent gravel study in Bokeo (SEACAP 17.02) confirmed the clear risk of unsustainable gravel loss on gradients greater than 6%. It is recommended therefore that the LRD gives serious consideration to spot improving further sections of the Samphan road. Failure to do so is likely to result in rapid deterioration of this newly acquired infrastructure asset.

Table 7 Project Risk Assessment

Task Group	Potential Risk	Risk Assessment at Inception	Actual problems encountered
1	Effective liaison with appointed contractor for programme planning	**Low risk**. Key stakeholders have indicated their desire to ensure cooperation	No problems encountered. Low risk assessment justified.
2	Lack of appropriate staff for training	**Low risk**. Key stakeholders have indicated their desire to ensure cooperation.	No major problems encountered, although a wider range of provincial staff available for training would have been desirable. Low risk assessment justified.
3	Cooperation of contractor in preparing earthworks on first 10 km for EOD training and investigation	**Low risk** to SEACAP 3.02 activity; training and trialling of manual can proceed. **Medium risk** to SEACAP 31 data collection	No problems for Manual trialling. Some delays to design data collection caused by earthwork preparation.
4	Delay in contractor preparing satisfactory earthworks, subgrade and drainage.	**Medium risk**. Field visit indicated that significant repair works might be required in October-November after end of rainy season	Delays to design and costing of trials sections on subgrade preparation and wearing course construction.
	Delays in construction of trial sections.	**High risk**. Even if construction starts there is a high risk that some sections may be completed and others not completed or completed in a rushed and unsatisfactory manner	Construction cancelled. High risk assessment justified.
	As-built survey completion	**High risk**. (see above)	As above.
5	Data management	**Low to medium risk** for EOD data input. **High risk** for as built survey data	Significant difficulties with compatibility of existing database with recovered data.
6	Final SEACAP 31 reporting delayed due to delays in Task Groups 3, 4 & 5	**Low risk** of reporting not completed but **high risk** of report not including all required information.	Trials construction cancellation has had significant impact on report content.

Acknowledgements’

This report was produced as part of the combine SEACAP 03.02-SEACAP 31 projects contracted to TRL Ltd in association with Lao Transport Engineering Consultant (LTEC) and OtB Engineering (International) Ltd The project team responsible for the drafting of this Final Report comprised Dr J R Cook (OtB Engineering),Simon Done (TRL), Bounta Meksavanh and Saysongkham Manodham (both of LTEC).

Invaluable support and guidance was supplied by the Sengdarith Kattignasack (LRD) and David Salter (SEACAP Programme Manager), who also provided facilitation, guidance and programme support.

The final Quality Assurance Review was undertaken by Simon Done.

TRIALLING THE NEW STANDARDS AND SPECIFICATIONS AND EXTENDING THE LAO LVRR SURFACE AND PAVING KNOWLEDGE BASE

SEACAP 3.02

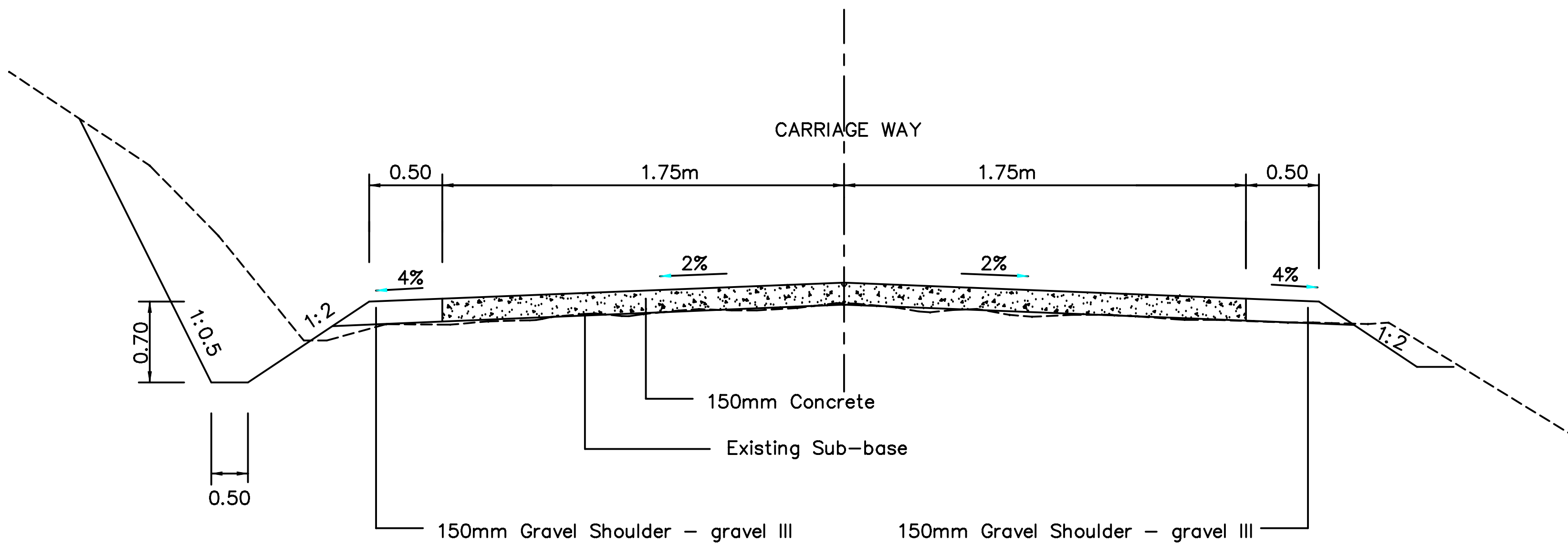
SEACAP 31

APPENDIX A

Trials Design Information

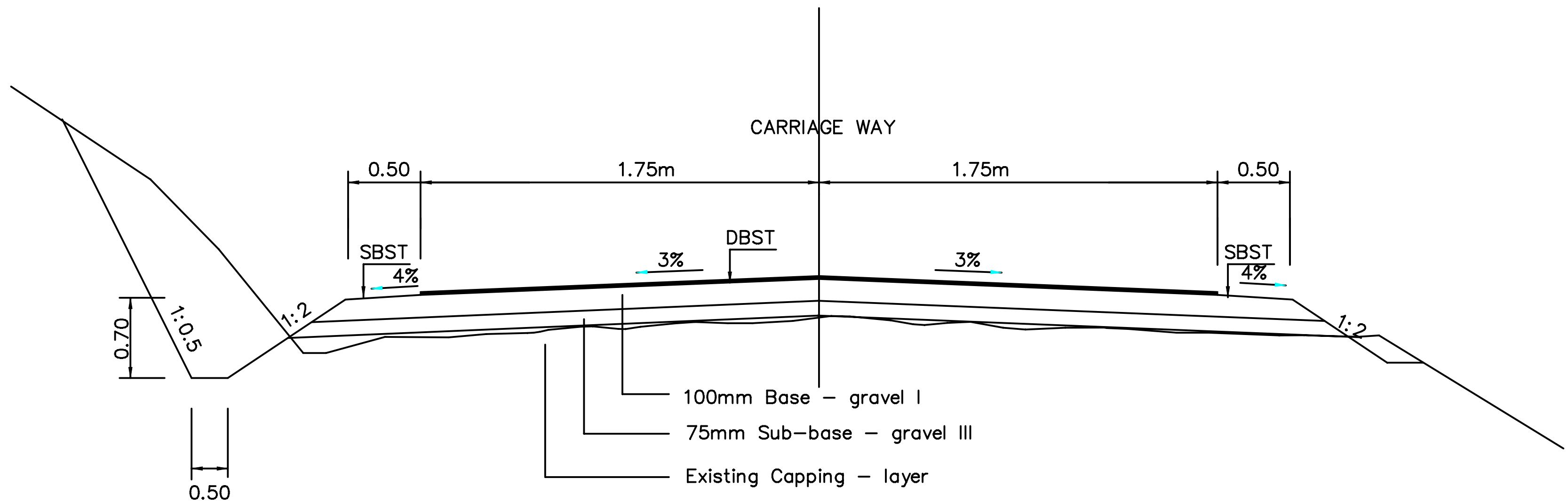
RRST STANDARD

TYPICAL CROSS SECTION S1 (KM0.000 – KM0.335)



RRST STANDARD

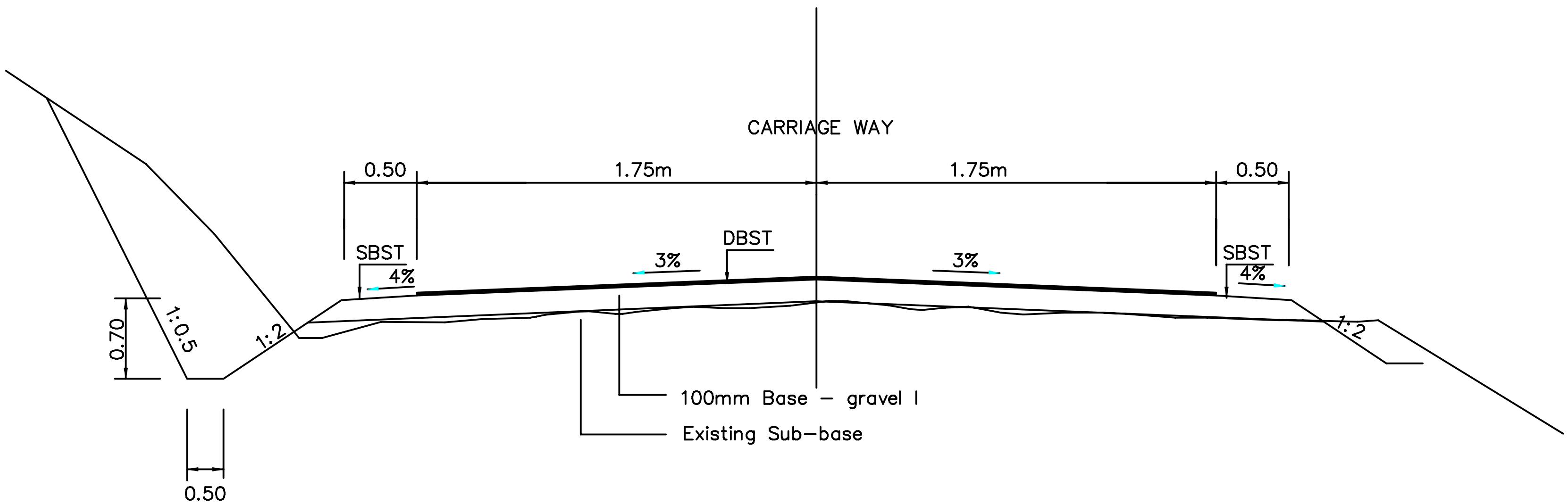
TYPICAL CROSS SECTION S2.1 (KM1.200 – KM1.400)



RRST STANDARD

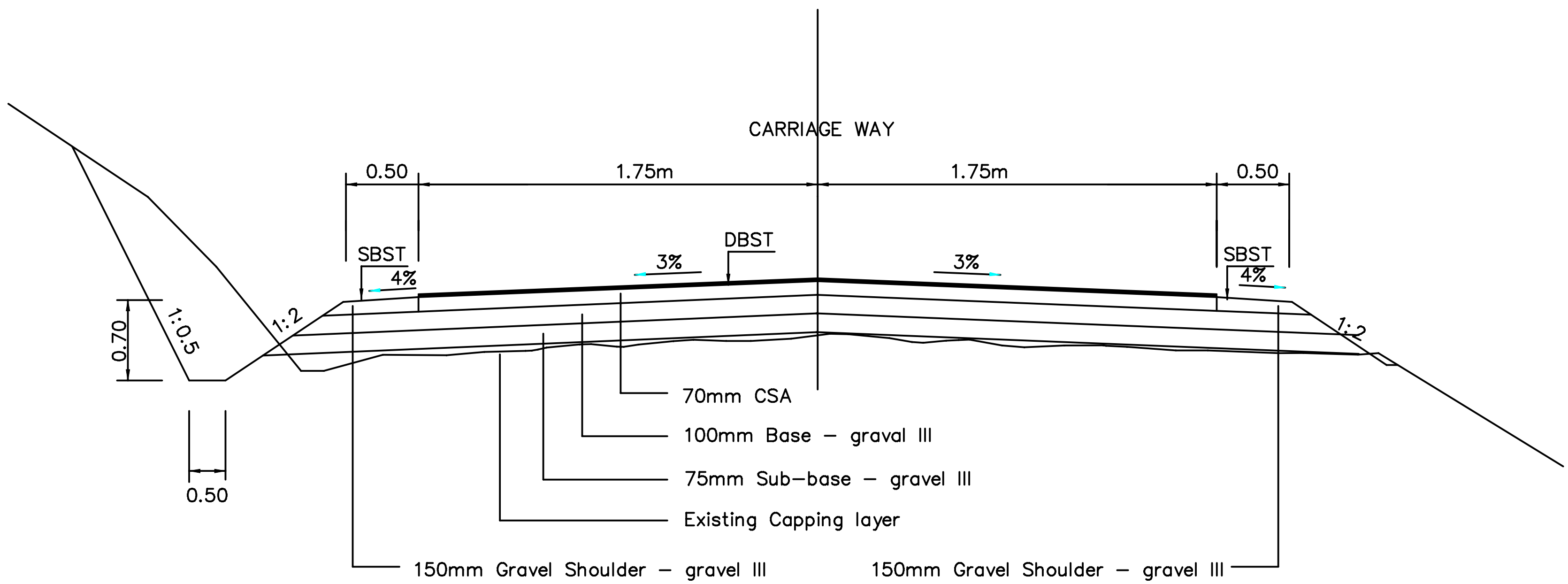
TYPICAL CROSS SECTION S2.2 (KM1.400 – KM1.700)

AND S3.2 (KM2.025 – KM2.100)



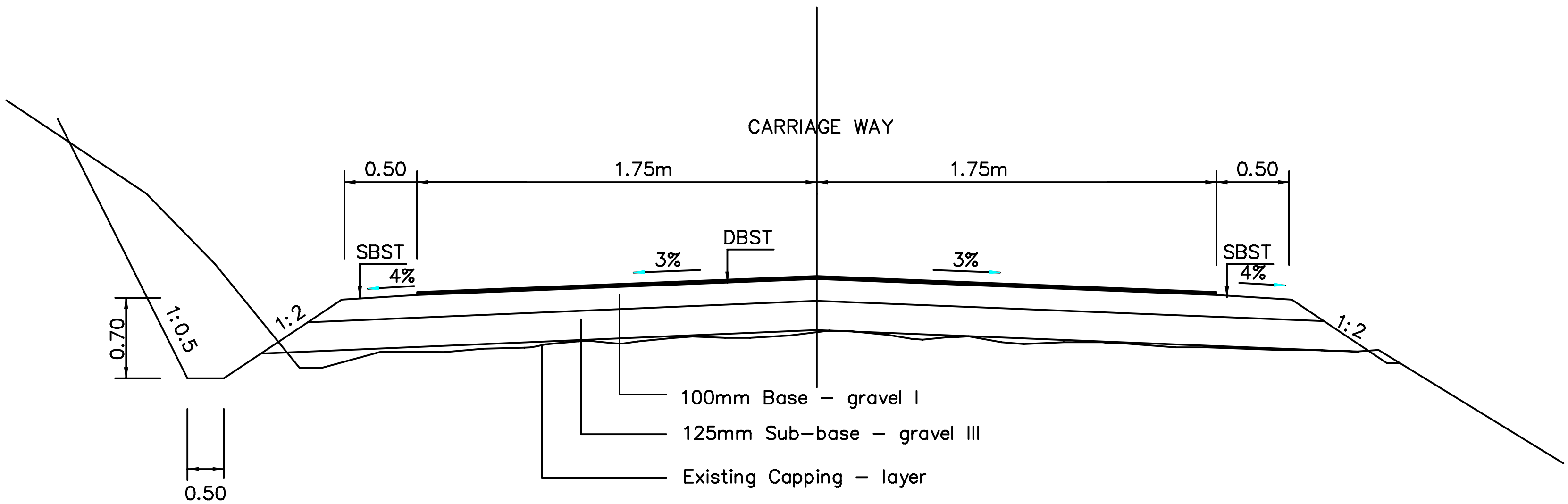
RRST STANDARD

TYPICAL CROSS SECTION S2.3 (KM1.700 – KM1.865)



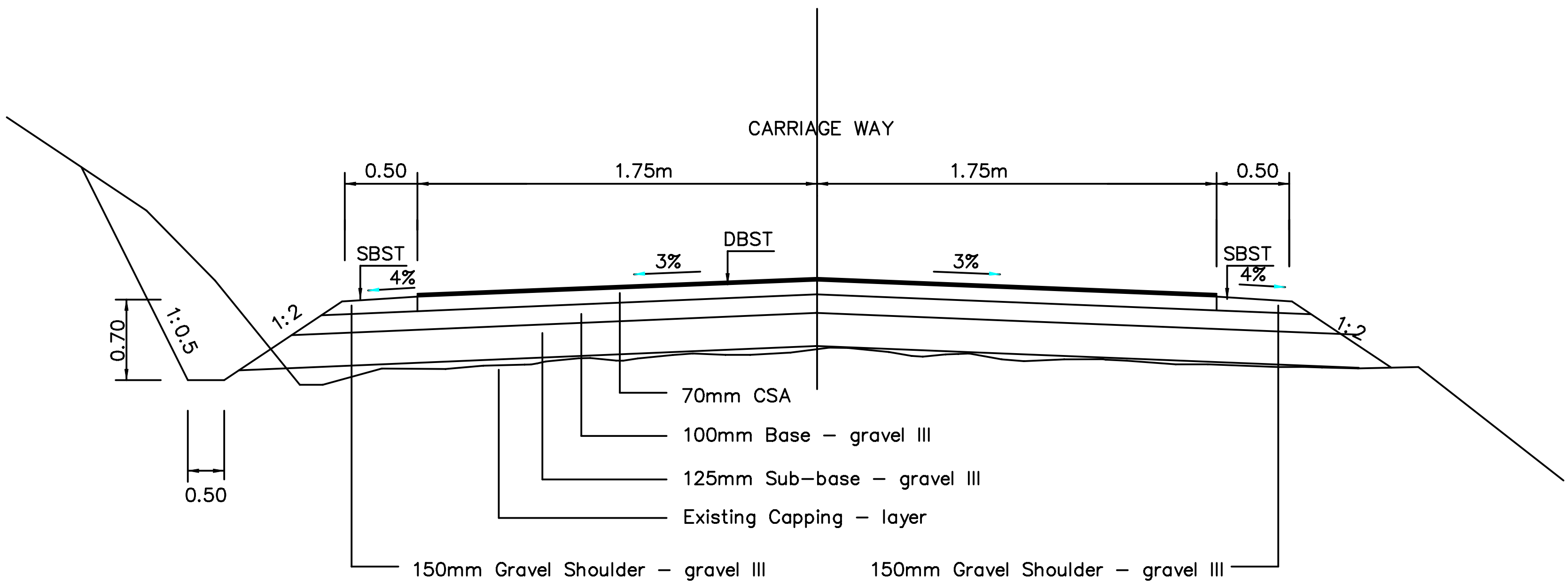
RRST STANDARD

TYPICAL CROSS SECTION S3.1 (KM1.950 – KM2.025)



RRST STANDARD

TYPICAL CROSS SECTION S4 (KM2.400 – KM2.520)



Bills of Quantity

PAVEMENT STRUCTURE

S1 (KM0.000 - KM0.335)

Item No.	Description	Unit	Qty	Rate US$	Amount US$
01	CSA	m^3	0		
02	Base	m^3	0		
03	Sub Base	m^3	0		
04	Shoulder Gravel	m^3	75	$11.09	$831.75
05	Concrete	m^3	176	$202.80	$35,692.80
06	Prime coat MC 70	litre			
	1 st Layer				
07	Bituminous binder	litre			
08	Chippings (14 mm)	m^3			
	2nd Layer				
09	Bituminous binder	litre			
10	Chippings (10 mm)	m^3			
	Total				**$36,524.55**

PAVEMENT STRUCTURE

S2.1 (KM1.200 - KM1.400)

Item No.	Description	Unit	Qty	Rate US$	Amount US$
01	CSA	m^3	0		
02	Base	m^3	100	57.74	5,774
03	Sub Base	m^3	75	11.09	832
04	Shoulder Gravel	m^3	0		
05	Concrete	m^3	0		
	DBST	m2	700	10.39	7,273
06	Prime coat MC 70	litre	840		
	1 st Layer				
07	Bituminous binder	litre	770		
08	Chippings (14 mm)	m^3	8		
	2nd Layer				
09	Bituminous binder	litre	700		
10	Chippings (10 mm)	m^3	5		
	Total				**13,879**

PAVEMENT STRUCTURE

S2.2 (KM1.400 - KM1.700)

Item No.	Description	Unit	Qty	Rate US$	Amount US$
01	CSA	m^3	0		
02	Base	m^3	108	57.74	6,236
03	Sub Base	m^3	0	11.09	
04	Shoulder Gravel	m^3	0		
05	Concrete	m^3	0		
	DBST	m2	1,050	10.39	10,910
06	Prime coat MC 70	litre	1,261		
	1 st Layer				
07	Bituminous binder	litre	1,156		
08	Chippings (14 mm)	m^3	12		
	2nd Layer				
09	Bituminous binder	litre	1,050		
10	Chippings (10 mm)	m^3	8		
Total					**17,145**

PAVEMENT STRUCTURE

S2.3 (KM1.700 - KM1.865)

Item No.	Description	Unit	Qty	Rate US$	Amount US$
01	CSA	m^3	40	63.51	2,540
02	Base	m^3	83	11.09	920
03	Sub Base	m^3	62	11.09	688
04	Shoulder Gravel	m^3	12		
05	Concrete	m^3	0		
	DBST	m2	578	10.39	6,005
06	Prime coat MC 70	litre	693		
	1 st Layer				
07	Bituminous binder	litre	636		
08	Chippings (14 mm)	m^3	6		
	2nd Layer				
09	Bituminous binder	litre	578		
10	Chippings (10 mm)	m^3	5		
Total					**10,154**

PAVEMENT STRUCTURE

S3.1 (KM1.950 - KM2.025)

Item No.	Description	Unit	Qty	Rate US$	Amount US$
01	CSA	m^3	0		
02	Base	m^3	38	57.74	2,194
03	Sub Base	m^3	47	11.09	521
04	Shoulder Gravel	m^3	0		
05	Concrete	m^3	0		
	DBST	m2	263	10.39	2,733
06	Prime coat MC 70	litre	315		
	1 st Layer				
07	Bituminous binder	litre	289		
08	Chippings (14 mm)	m^3	3		
	2nd Layer				
09	Bituminous binder	litre	263		
10	Chippings (10 mm)	m^3	2		
Total					**5,448**

PAVEMENT STRUCTURE

S3.2 (KM2.025 - KM2.100)

Item No.	Description	Unit	Qty	Rate US$	Amount US$
01	CSA	m^3	0		
02	Base	m^3	27	57.74	1,559
03	Sub Base	m^3	0	11.09	
04	Shoulder Gravel	m^3	0		
05	Concrete	m^3	0		
	DBST	m2	263	10.39	2,733
06	Prime coat MC 70	litre	315		
	1 st Layer				
07	Bituminous binder	litre	289		
08	Chippings (14 mm)	m^3	3		
	2nd Layer				
09	Bituminous binder	litre	263		
10	Chippings (10 mm)	m^3	2		
Total					**4,292**

PAVEMENT STRUCTURE

S4 (KM2.400 - KM2.520)

Item No.	Description	Unit	Qty	Rate US$	Amount US$
01	CSA	m^3	29	63.51	1,842
02	Base	m^3	60	11.09	665
03	Sub Base	m^3	75	11.09	832
04	Shoulder Gravel	m^3	9		
05	Concrete	m^3	0		
	DBST	m2	420	10.39	4,364
06	Prime coat MC 70	litre	504		
	1 st Layer				
07	Bituminous binder	litre	462		
08	Chippings (14 mm)	m^3	5		
	2nd Layer				
09	Bituminous binder	litre	420		
10	Chippings (10 mm)	m^3	3		
Total					**7,703**

Contractor Costs

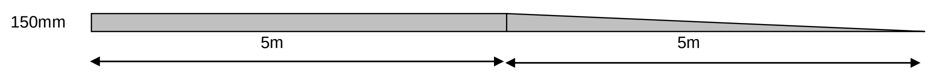
		I Contractor Proposal		III Current Negotiated	
	Unit	**Cost (kip)**	**Cost US$**	**Kip**	**US$**
DBST Seal	m2	95,000	10.97	90,000.00	10.39
Capping Layer	m3	90,000	10.39	75,000.00	8.66
G W C (Gravel III)	m3	250,000	28.87	96,000.00	11.09
Gravel II	m3	480,000	55.43	480,000	55.43
Gravel I	m3	500,000	57.74	500,000	57.74
Crushed Stone Agg (CSA)	m3	550,000	63.51	550,000	63.51
Non Reinforced Concrete	m3	2,500,000	288.68	1,750,000.00	202.08
Existing contract Gravel	**m3**	**50,000**	**5.77**		

US$1= kip8660

Detail of Transitions between Spot Improvement Sections

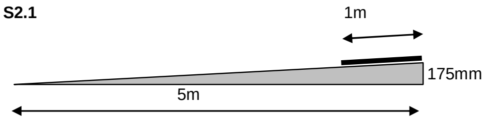
Proposed transitions between pavement and surfacing types

T1 S1 to GWC



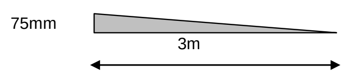
A	5.0 x 0.15 x 5	3.75	m3	Gravel III
B	2.5 x 0.15 x 5	1.88	m3	Gravel III
	Total	5.63	m3	Gravel III

T2 Gravel to S2.1



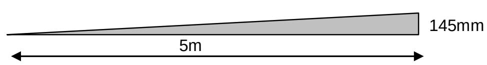
A	2.5 x 0.175 x 5	2.19	m3	Gravel III
B	1 x 3.5	3.50	m2	DBST

T3 S2.1-S2.2



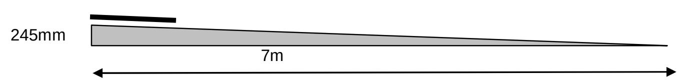
A	1.5 x 0.075 x 5	0.56	m3	Gravel I

T4 S2.2-S2.3



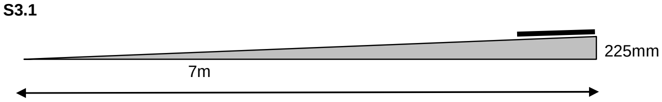
A	2.5 x 0.145 x 5	1.81	m3	Gravel I

T5 S2.3 - GWC



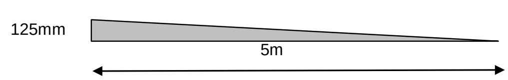
A	3.5 x 0.245 x 5	4.29	m3	Gravel III
B	1 x 3.5	3.50	m2	DBST

T6 GWC to S3.1



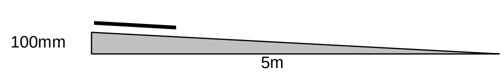
A	3.5 x 0.225 x5	3.94	m3	Gravel III
B	1 x 3.5	3.50	m2	DBST

T7 S3.1 to 3.2



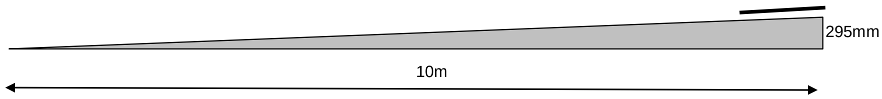
A	2.5 x 0.125 x 5	1.56	m3	Gravel I

T8 S3.2 to GWC



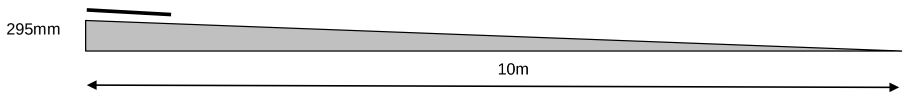
A	2.5 x 0.1 x 5	1.25	m3	Gravel I
B	1 x 3.5	3.50	m2	DBST

T9 GWC to S4



A	5 x 0.295 x 5	7.38	m3	Gravel III
B	1 x 3.5	3.50	m2	DBST

T10 S4 to GWC to S4



A	5 x 0.295 x 5	7.38	m3	Gravel III
B	1 x 3.5	3.50	m2	DBST

TRANSITION COST SUMMARY

	Gravel I			Gravel III			Seal		
	m3	**Rate**	**Cost**	**m3**	**Rate**	**Cost**	**m2**	**Rate**	**Cost**
T1	0			5.63			0		
T2	0			2.29			3.5		
T3	0.56			0			0		
T4	1.81			0			0		
T5	0			4.29			3.5		
T6	0			3.94			3.5		
T7	1.56			0			0		
T8	1.25			0			3.5		
T9	0			7.83			3.5		
T10	0			7.83			3.5		
Totals	**5.18**	**$57.74**	**$299.09**	**31.81**	**$11.09**	**$352.77**	**21**	**$10.39**	**$218.19**

Gravel I	$299.09
Gravel III	$352.77
DBST	$218.19
Total	**$870.06**

TRIALLING THE NEW STANDARDS AND SPECIFICATIONS AND EXTENDING THE LAO LVRR SURFACE AND PAVING KNOWLEDGE BASE

SEACAP 3.02

SEACAP 31

APPENDIX B

Samphan Road Data Collection Report

2nd to 9th of May 2009

SEACAP 31/001 Amendment No. 3

Data collection and training report: Phongsali Province

2nd to 9th of May 2009

1. Introduction

1.1 Background

Under SEACAP 31 it had been proposed to design and construct a number of spot improvement trials on the Samphan road in Phonsali province, Plate 1. However, due to the price of the improvements proposed by the contractor being higher than expected and the short time available for the work to be completed, the construction was cancelled. The contractual arrangements for the supervision of the construction were then amended to include additional survey work of the as constructed road sections in conjunction with training of Provincial staff, to be carried out over a week in early May 2009.

This report describes the work carried out during the week of survey and training and the subsequent analysis and discussion. Further details of this work together with tabulations of all data are held on the LTEC computer system in Vientiane.

1.2 Objectives

The objectives of the week in Phongsali Province and the subsequent analysis and discussion were as follows:

- Carry out a detailed survey of the 4 trial sections, totalling 1285 metres, between the following chainages:
    - 0+000 – 0+350
    - 1+200 – 1+865
    - 1+950 – 2+100
    - 2+400 – 2+520
- Compare the results of these surveys with the contract specifications to assess the quality of construction
- Compare the results with the assumptions made when designing the spot improvements and thereby assess the suitability of the designs
- Carry out a rapid condition survey of the remainder of the road
- Train Phongsali DPWT & OPWT staff and others in the survey methods
- Make a general assessment of the standard of the completed work and the selection and design of further spot improvements

2 Programme

2.1 Resources

A SEACAP 31 team was mobilised from Vientiane comprising an LTEC survey group with recent experience from the parallel SEACAP 17.02 project under the management of Simon Done. In addition a number of local engineers also took part in the work as a hands-on training exercise. These participants are listed in Table 1.

Table 1 Training participants

Mr Bounthavy Sosoukhanh	Project Manager of Samphan Road and Director of Roads and Bridges, DPWT Phongsali (part time attendance)
Mr Chansom Outthachack	Deputy Project Manager of Samphan Road and Head of Rural Roads Unit, DPWT Phongsali
Mr Khaysy Visounnalat	LSRSP site supervisor on Samphan Road
Mr Xaysompheth Siphan	DPWT Phongsali
Mr Sengdeuan Keosomephan	DPWT Phongsali
Mr Vongdeuan Phoummytham	DPWT Phongsali
Mr Khamlue *	DPWT Phongsali
Mr Xay *	OPWT Khoa
Mr Xiengbounsom Kanbandit	OPWT Samphan
Mr Nou Sonekhamxay	Contractor's site engineer on Samphan Road (part time attendance)

* the only two participants who did not attend the SEACAP 31 training workshops during 2008

2.2 Programme

The programme was as follows:

- 2nd May – SEACAP team flew or drove to Oudomxay
- 3rd May – Detailed site planning and travelled to Khoa (LTEC team subsequently moved to accommodation in Paknamnoi and Bouampan)
- 4th-7th May– trial sections were surveyed by teams comprising LTEC and Phongsali staff, Simon Done carried out rapid condition surveys of the road
- 8th May – all participants carried out a rapid survey of entire road, Phongsali staff explaining general principles of spot improvement to the LTEC staff
- 9th – left Khoa, SEACAP 31 main team arriving in Vientiane on the 11th..

2.3 Assessment of Specifications

The principal details of the specification for the gravel wearing course are as follows;

150mm of gravel wearing course forming a 3.5m wide carriageway with a 5% crossfall over subgrade with a soaked CBR of >8% in the top 300mm and >4% in the 700mm below this.

The gravel should be lateritic or a lateritic/natural gravel mix. Two classes of gravel are described in the Lao standard gravel specification, as given in Table 2. The specifications for Class 1 were assumed to be used.

Table 2 Gravel specifications

	Class 1	Class 2
Grading		
Sieve (mm)	Percentage passing by weight	
50	100	100
37.5	90-100	90-100
25	65-95	75-95
9.5	45-75	50-85
4.75	30-65	35-75
2	20-50	25-60
0.425	10-30	15-40
0.075	5-10	5-30
Plasticity		
Liquid Limit % (max)	40	50
Plasticity Index % (max)	15	20
Particle Strength		
Los Angeles Abrasion Value (max)	45	45
Strength		
Soaked CBR % (min)	25	20

Side drains were required to be V-shaped with a depth of 700 mm from the edge of the carriageway. Cut slopes above the road should comply with the specifications in Table 3. Any slopes higher than 4 metres should be benched with a step at least 1.5 metres wide and an inward slope of 2%.

Table 3 Cut slope specifications

Height (m)	Vertical:horizontal		
	Soil	Soft rock	Hard rock
0-1	1:2	1:2	4:1
1-3	1:1	1:1	4:1
> 3	2:1	2:1	4:1

Down slopes below the road should be no steeper than 1:2 and no loose material should be dumped on the down slopes.

3 Summary of Work Undertaken

3.1 Detailed Condition Surveying

The following procedure were used

DCP: Five DCP tests were carried out per cross-section– on the centre line, in both wheeltracks and at the shoulders – at a spacing of 50 metres along all 4 trial sections, giving a total of 140 tests.

MERLIN: The roughness of each wheeltrack along all 4 trial sections was measured in 100 metre lengths using the MERLIN equipment.

Carriageway level survey: An automatic level, staff and tripod was used to accurately measure the cross section profiles, including the cambers, of the road with one point on the centreline and 4 points at 500 mm spacing on either side. Cross sections were measured at a spacing of 50 metres along all 4 trial sections, giving a total of 29 cross sections. The levels were referenced to TBMs installed alongside the road so that changing levels can be measured over time and cross sections were also referenced to each other so that gradients of the trial sections could be calculated.

Visual surveys: A detailed visual survey of the carriageway, shoulders and side drains was made by dividing the road surface into 5 metre blocks and then assessing aspects such as loose material, rutting, erosion and potholes on either side of the road, using defined codes for differing degrees of damage and extent. A visual survey was made of all 4 trials sections.

Gravel spot surveys: A gravel spot survey was made by assessing a single 10 metre block at a spacing of approximately 150 metres. For each block a variety of assessments such as width, erosion, camber, gradient, drainage condition and gravel thickness (using test pits) are made, using defined codes for differing degrees of damage and extent. A total of 10 gravel spot surveys were carried out on the trial sections.

3.2 Site records

A selection of the available records were requested from DPWT Phongsali during the survey and training week and sent to Vientiane shortly afterwards. It was recognised that the full set of records that might be expected on a site of this type and size might not be available

3.3 Laboratory testing in Vientiane

Gravel samples were taken from each gravel spot survey location and 4 gravel borrow pits along the road. These samples were taken back to Vientiane and tested by LTEC for grading and plasticity.

3.4 Rapid condition surveys

A series of rapid condition survey methods were trialled along the entire road, each with the objective of making an initial identification of the sites where further improvements, such as an improved surface, are appropriate and possibly also identifying major defects along the remainder of the road. These survey methods can be summarised as follows.

- A foot survey in which successive 50 metre blocks are assessed for gradient and the condition of the side slopes, side drains, shoulder, gravel quality and carriageway surface. This survey is similar to the visual survey but quicker and in less detail.

- A foot survey in which the chainages of changes in gradient or lateral terrain or of significant features such as the start of a village or hill or sites of erosion are recorded. This survey identifies defects and sections which are uniform in gradient and terrain and is quicker but records less detail than the first survey.

- A foot survey in which a GPS device is used to record the chainage and elevation of sites along the road. This main focus of this survey is on gradients, although other significant features and defects could also be recorded. It is quicker than the first two surveys.

- A car survey in which the trip meter is used to record the sites where further improvements might be appropriate.

4. Site Data analysis

4.1 In situ gravel strength

The DCP results were analysed into a series of layers, each with a measured strength. The thickness of the upper layer in each test varies from 39 mm to over 400 mm and there is no consistent pattern of lower layers being weaker than the layers above, probably because the gravel was compacted onto a reasonably strong cut surface rather than looser fill material. Instead of trying to establish a composite strength of the upper 150 mm, the gravel strength is simply taken to be the strength of the upper layer, regardless of its thickness. Table 5 gives an analysis of these upper layer in situ CBR strengths.

Table 4 Strengths of upper layers

CBR strength of upper layer	Number of tests
< 10	0
10-14	1
15-19	4
20-24	23
25-29	33
30-34	32
35-39	20
40-44	16
45-49	2
50 or more	9

It can be seen that approximately 20% of the upper layer DCP-CBR strengths are less than 25%, with only 4% less than 20%.

The DCP-CBRs for the upper 150mm were then further analysed by location,Figure 1. The numbers 1 to 5 merely identify the tests from left to right. Grey indicates a test marginally below 25%, and black a CBR definitely below 25%.

Figure 1 Compliance of upper 150 mm with specification

Section 1	Inside Shoulder	W/T	CL	W/T	Outside Shoulder
0	1	2	3	4	5
50	1	2	3	4	5
100	1	2	3	4	5
150	1	2	3	4	5
200	1	2	3	4	5
250	1	2	3	4	5
300	1	2	3	4	5

Section 2	Inside Shoulder	W/T	CL	W/T	Outside Shoulder
1200	1	2	3	4	5
1250	1	2	3	4	5
1300	1	2	3	4	5
1350	1	2	3	4	5
1400	1	2	3	4	5
1450	1	2	3	4	5
1500	1	2	3	4	5
1550	1	2	3	4	5
1600	1	2	3	4	5
1650	1	2	3	4	5
1700	1	2	3	4	5
1750	1	2	3	4	5
1800	1	2	3	4	5
1850	1	2	3	4	5

Section 3	Outside Shoulder	W/T	CL	W/T	Inside Shoulder
1950	1	2	3	4	5
2000	1	2	3	4	5
2050	1	2	3	4	5
2100	1	2	3	4	5

Section 4	Outside Shoulder	W/T	CL	W/T	Inside Shoulder
2400	1	2	3	4	5
2450	1	2	3	4	5
2500	1	2	3	4	5

On the basis of the analysis 88 tests (63%) were acceptable, 35 (25%) tests were marginal and 17 (12%) tests were failed, more tests being out of specification than in Table 4 because thickness was also taken into account. The failed and marginal tests are more common along the shoulders of the road than along the centre. This is presumably due to greater overlapping of the roller passes in the centre of the road, with less attention being paid to the shoulders, which is a not uncommon but nevertheless unfortunate practice. This analysis is valid only if there is direct relationship between the DCP-CBR and the required CBR strength based on adequate compaction of suitable material (laboratory CBR=25%)

4.2 Gravel thickness by strength variation

As suggested above, it was not possible to reliably identify a clear boundary between the gravel and the layer below, either by a change in strength at around 150 mm deep or by a weaker layer underlying the gravel, presumably because the gravel was compacted onto a reasonably strong cut surface rather than looser fill material.

4.3 Subgrade strengths

For the purposes of this analysis, layers under the gravel will be referred to as 'subgrade'. The DCP results were analysed and the in situ strength at a depth of 250 mm was recorded, this giving some indication of the strength of the layer supporting the gravel.

The average DCP-CBR subgrade strengths for each Section were as follows;

Section 1	25%
Section 2	27%
Section 3	31%
Section 4	35%

The lowest strength of any test is 8% and the lowest 10^{th} percentile strength is 13%. There is some variation from one section to another, although this may be caused by a small number of stray results. In trial sections 1 and 2, there is no obvious subgrade weakness on the outside shoulders. In trial sections 3 and 4, there is a possible subgrade weakness on the outside shoulders, particularly in section 4. In all cases the DCP-CBR subgrade strengths are considerably higher than the specification requirements and are unlikely to indicate a road constructed on loose dumped material. However, it should be emphasised that these are DCP-CBR values on a an unsealed road and would need to correlated with laboratory Soaked CBR value and/or in situ density tests before firm comment could be made as values to be used for pavement design.

4.4 Merlin

The results for each 100 metre length (or less) in each wheeltrack, and the average of both wheeltracks, are presented in Table 5.

Table 5 IRI values of the trial sections along the wheeltracks

T = 6 mm
S = 35 mm
Scaling factor = 1.714

IRI = 0.593 x 0.0471 D

Chainage		Left			Right			Average
From	To	L	D	IRI	L	D	IRI	IRI
Section 1								
0	100	123	211	10.5	108	185	9.3	**9.9**
100	200	117	201	10.0	104	178	9.0	**9.5**
200	335	95	163	8.3	102	175	8.8	**8.5**
Section 2								
1200	1300	87	149	7.6	87	149	7.6	**7.6**
1300	1400	73	125	6.5	111	190	9.6	**8.0**
1400	1500	104	178	9.0	103	177	8.9	**8.9**
1500	1600	90	154	7.9	110	189	9.5	**8.7**
1600	1700	94	161	8.2	120	206	10.3	**9.2**
1700	1865	92	158	8.0	103	177	8.9	**8.5**
Section 3								
1950	2100	114	195	9.8	118	202	10.1	**10.0**
Section 4								
2400	2520	97	166	8.4	102	175	8.8	**8.6**

These values appear to be slightly on the high side for a recently completed gravel road. This may be due to the inherent nature of these generally coarse materials being derived from in situ weathering profiles rather than being true "natural gravels".

4.5 Carriageway level survey

The results of the carriageway level survey were analysed and referenced to the series of TBMs and an arbitrary level established at the 0+100 TBM using the GPS. The results were then analysed in order to calculate the camber of the road at each of the 29 cross sections. Most of the carriageway has a camber of less than 5%, particularly in the central 2 metres where the wheeltracks are likely to form shallow ruts, and where adequate camber is, for exactly that reason, particularly important. The majority of the carriageway is therefore inadequately cambered, most likely due to poor quality control since there has been minimal opportunity yet for traffic to reduce the camber.

This poor camber is likely to significantly increase the rate of deterioration of the road surface through longitudinal erosion during the rainy season.

It is also possible to use the carriageway level survey to calculate the gradients of each 50 metre length of the trial sections. These gradients are presented in Table 6 and compared with gradients estimated in 2008 using the hand level and used to select trial sections 2, 3 and 4 for spot improvements. In some places direct comparison is not possible because the hand level survey was carried out between locations where the gradient was judged to be changing and the carriageway level survey was carried out at a consistent spacing of 50 metres, but a reasonable comparison is still possible.

Table 6 Comparison of measured gradients

Hand level survey 2008			**Carriageway level survey 2009**		
Chainage		**Gradient**	**Chainage**		**Gradient**
From	**To**		**From**	**To**	
Section 1					
0	50	7	0	50	7.7
50	120	5	50	100	4.5
120	135	3.5	100	150	3.7
135	188	1	150	200	0.3
188	230	2	200	250	0.4
230	260	3			
260	300	7	250	300	6.8
Section 2					
1200	1250	10	1200	1250	9.1
1250	1300	11	1250	1300	11.4
1300	1350	9	1300	1350	8.2
1350	1400	7	1350	1400	6.1
1400	1450	5	1400	1450	3.2
1450	1500	7	1450	1500	6.1
1500	1550	6	1500	1550	5.5
1550	1615	7	1550	1600	7.0
1615	1700	9	1600	1650	9.0
			1650	1700	9.6
1700	1760	9	1700	1750	7.4
1760	1865	10	1750	1800	9.8
			1800	1850	6.3
Section 3					
1950	2100	7	1950	2000	5.2
			2000	2050	8.8
			2050	2100	3.9
Section 4					
2400	2520	7	2400	2450	6.1
			2450	2500	7.9

This table shows very good correlation between the hand level survey and the carriageway level survey, confirming that the selection of trial sections was reasonable, although it is acknowledged that the gradient of the intermediate sections was not checked to be less than 6%. The table also confirms that the hand level is an accurate and therefore useful survey instrument.

4.6 Gravel spot surveys

A summary of key measurements were made during this survey and are presented in Table 7. The carriageway width, gravel thickness and camber results which are clearly out of specification are in **Bold** and highlighted in grey

Table 7 Measurements made during the gravel spot survey

Chainage	Carriageway width (m)	Gravel thickness (mm)	Camber left (%)	Camber right (%)	Gradient (%)
100	3.5	150	**0.0**	**0.0**	5.0
250	3.5	**80**	**3.5**	**4.0**	5.0
1240	3.5	**130**	**2.0**	**4.0**	11.0
1400	3.5	140	**4.0**	**2.5**	3.0
1550	3.5	**90**	**2.0**	6.5	8.0
1700	3.5	**130**	**0.0**	9.0	8.5
1850	3.5	**140**	4.5	**3.0**	4.5
1980	3.2	**100**	8.0	**0.0**	4.0
2100	3.5	140	5.0	**1.5**	1.0
2460	3.5	**100**	**0.0**	**0.0**	10.0

The measured carriageway widths are adequate, only one cross section being out of specification, although it is noted that the segregated and unstable shoulders are likely to deteriorate rapidly and reduce the carriageway width.

The gravel spot survey, with small test pits, has allowed gravel thicknesses to be checked and, at almost half of the survey sites, found to be no more than two thirds of the required thickness.

The cambers measured during the gravel spot survey with a straight edge, spirit level and tape measure confirm the conclusion of the carriageway level survey, namely that the cambers are inadequate, although the agreement between the two measurements at specific chainages is no better than fair. Camber measurement with automatic level is more accurate than with a straight edge and so the measurements during the carriageway level survey should be used in preference to those from the gravel spot survey.

4.7 Road condition

Despite the lack of time for full detailed analysis, the results of the gravel spot survey gives indications of suspect construction quality and initial deterioration, such as minor rutting, small erosion rills and, as above, inadequate camber.

4.8 Traffic counting

A formal traffic count was not possible during short time spent on Samphan Road, nevertheless, the following observations were made.

- By observation the traffic levels were seen to be very low
- Occasional contractor heavy equipment was seen on the road, Plate 2
- Some private trucks, heavier than a small Kolao truck, the vehicle for which the spot improvements were designed, were seen on the road
- Around five 4-wheeled motorised vehicles were seen per day on the first 5 kilometres of the road
- Traffic levels seem to drop significantly from that low level after the first 5-10 kilometres
- Traffic levels are variable, higher on the Wednesday, perhaps due to the market at Akcher, 20 kilometres along the road, than on the Thursday when no 4-wheeled motorised vehicles were seen
- The number of motorbikes is perhaps 5-10 times the number of 4-wheeled motorised vehicles
- No farm tractors were seen all week
- Participants comments that traffic is likely to rise rapidly now that the road is opened to Samphan

5 Laboratory Test Results

5.1 Construction records

Construction records, made between October 2008 and February 2009, included soaked CBR tests, density-moisture curves, grading analysis and plasticity analysis from 9 gravel sources along the length of the road and 4 field density measurements of the top 100-150 mm in the first 3.1 kilometres. It is assumed that the gravel sources were tested as part of the approval process and that the field density tests were of the gravel layer. It is noted from the records that the gravel samples were collected by the contractor and not by the DPWT laboratory staff who carried out the tests. No other records were provided. It is not known whether or not more records have been made.

The results of the soaked CBR tests, grading analysis and plasticity analysis are summarised in Table 8

Table 8 Summary of DPWT laboratory test results

LAO PEOPLE'S DEMOCRATIC REPUBLIC
Peace Independence Democracy Unit Properity

Department of Public Works and Transport
Road and Bridge Office
Laboratory Unit

No---------/RB

SUMMARY OF THE TEST RESULT OBTAINED

Project: Lao Swedish Road Sector Project III-MC FY 2007-2008, Sida Grant
Contract No: O8O2O3
Contractor: Phonxay Irrigation and Road-Bridge Construction Co;LTD

Item	Sample detail	Location Km	PERCENT PASSING SIEVE SIZE (mm)									ATTERBERG		COMPACTION		CBR AT % COMPACTION			REMARK
			50	37.5	25	19	9.5	4.75	2	0.425	0.075	LL	PI	MDD	OMC	100	98	95	
1	From Borrow-pit	1+650	100	79	64		46	14	8	6	5	64	32.89	1.895	10.23	37	35	33	
	Wearing Course	16+200	100	87	74		60	41	28	18	5	46	20.49	1.939	13.5	43	39	30	
		21+000 (1)	100	78	50		39	14	9	6	6	73	34.97	1.810	15.8	27	26	23	
		21+000 (2)	100	79	64		46	14	10	8	8	60	23.74	1.945	10.2	48	31	24	
		21+000(Mix)	100	78	68		50	14	9	7	6	60.9	27.73	1.841	13.7	42	36	29	
		26+150	100	88	57		42	12	8	6	5	57.1	21.87	1.744	17.8	70	59	44	
		35+200	100	96	46		19	10	8	7	6	46.6	20.5	1.910	13.6	101	76	48	
		37+400	97	55.3	36		27	12	11	9	8	48.5	18.52	1.860	10	63	47	38	
		45+100	91	88	74		24	11	7	5	3	42	9.51	1.895	8	62	53	38	

Phongsaly, date:

Head of Road and Bridge Office ***Chief of Laboratory***

The four field density tests give densities significantly above 95% MDD, although the calculations should be checked before these values are confirmed. However, site observations of a hard surface which does not appear to deflect or form ridges under traffic, even large construction trucks, suggest that field densities are high and that the soaked CBR strengths are likely to have been achieved on the road.

5.2 Gravel type

The gravel is not a lateritic or natural gravel as required in the specifications. The following paragraphs compare the strength, grading, plasticity and thickness results from the various surveys and testing described above.

5.3 Gravel strength

Table 9 shows the results from the 2008 soaked CBR tests at 95% MDD (modified AASHTO), presumably when gravel sources were being tested as part of the approval process. The results which are below the specified CBR strength of 25% are highlighted.

Table 9 Soaked CBR strengths of gravel sources

Sample detail	Location Km	COMPACTION		CBR AT % COMPACTION		
		MDD	OMC	100	98	95
From Borrow-pit	1+650	1.895	10.23	37	35	33
Wearing Course	16+200	1.939	13.5	43	39	30
	21+000 (1)	1.810	15.8	27	26	23
	21+000 (2)	1.945	10.2	48	31	24
	21+000(Mix)	1.841	13.7	42	36	29
	26+150	1.744	17.8	70	59	44
	35+200	1.910	13.6	101	76	48
	37+400	1.860	10	63	47	38
	45+100	1.895	8	62	53	38

Only two samples, from the same gravel source, are out of specification. The source at chainage 1+650, which is likely to have been the source used for the trial sections, has a soaked strength of 33%. The remainder of the gravel sources have soaked strengths between 29% and 48%.

5.4 Gravel grading and plasticity

The grading and plasticity results from the DPWT Phongsali testing for gravel approval in 2008 and the SEACAP 31 testing in Vientiane in 2009 are presented in Table 10. Highlighted cells indicate results that are out of specification.

The samples collected by the contractor and tested by DPWT Phongsali in 2008 fail almost completely on grading and plasticity. The samples taken in 2009 are better on grading and plasticity, although many have too high a proportion of fines and some have a high plasticity index

Therefore, in contrast to the gravel strength the grading and plasticity results are significantly out of specification., Plate 3

Table 10 Gravel grading and plasticity results

Contract specification		Plasticity		Grading percentage passing sieves (mm)							
		LL (%)	PI (%)	50	37.5	25	9.5	4.75	2	0.425	0.075
		< 40	< 15	100	90-100	65-95	45-75	30-65	20-50	10-30	5-20

Gravel approval testing in 2008		Plasticity		Grading percentage passing sieves (mm)							
	Chainage	LL (%)	PI (%)	50	37.5	25	9.5	4.75	2	0.425	0.075
Borrow pits	1650	64	32.89	100	79	64	46	14	8	6	5
	16200	46	20.49	100	87	74	60	41	28	18	5
	21000 (1)	73	34.97	100	78	50	39	14	9	6	6
	21000 (2)	60	23.74	100	79	64	46	14	10	8	8
	21000 (mix)	60.9	27.73	100	78	68	50	14	9	7	6
	26150	57.1	21.87	100	88	57	42	12	8	6	5
	35200	46.6	20.5	100	96	46	19	10	8	7	6
	37400	48.5	18.52	97	55.3	36	27	12	11	9	8
	45100	42	9.51	91	88	74	24	11	7	5	3

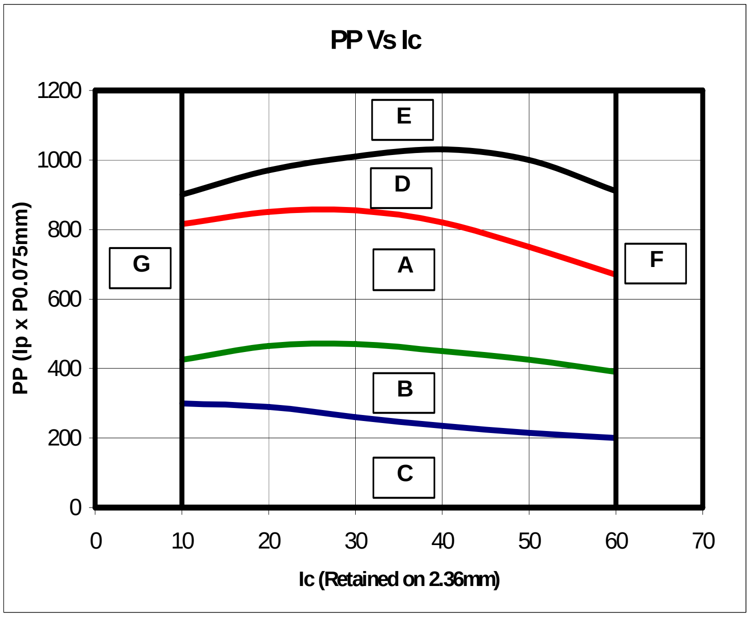
Gravel testing in 2009			Plasticity		Grading percentage passing sieves (mm)							
		Chainage	LL (%)	PI (%)	50	37.5	25	9.5	4.75	2	0.425	0.075
Test pits	TP01	100	49.3	20.8	100	97	80	54	46	37	31	29
	TP02	250	38.2	13.4	100	100	100	68	55	44	36	33
	TP03	1250	34	11.1	100	100	98	73	56	42	32	29
	TP04	1400	32.4	9.3	100	100	94	58	43	31	21	18
	TP05	1550	42.3	17.2	100	100	100	70	57	46	38	36
	TP06	1700	31.4	8.6	100	100	96	50	31	18	11	10
	TP07	1850	38	14.2	100	100	99	56	41	29	21	19
	TP08	1980	37.9	14.2	100	100	87	53	39	28	19	17
	TP09	2100	35.7	11.5	100	100	88	49	34	24	17	15
	TP10	2460	37	12.5	100	100	95	68	56	45	35	32
Borrow pits	BP01	3400	26	6.2	100	100	100	54	34	19	9	7
	BP02	12600	45.4	19.6	100	100	100	61	47	38	32	29
	BP03	24700	38.8	14.6	100	100	92	54	44	36	31	29
	BP04	48800	45.2	19.2	100	81	67	39	32	27	23	22

Although most specifications specify material properties in terms of grading and plasticity, there are alternative means of assessing gravel, often combining grading and plasticity,

Some of these alternative means of assessment use slightly different sieve sizes, for example 2.36 mm and 26.5 mm sieves, instead of the 2 mm and 25 mm sieves used above. For the purposes of this report, variables have been calculated using the nearest equivalent sieve sizes, although it is noted that this may marginally affect the results of these calculations.

Figure 2 presents a standard a chart used to assess gravel performance, depending upon which of the 7 regions of the chart its result place it. Ic is the coarseness index and is the percentage retained on the 2.36 mm sieve. Plasticity Product is the Plasticity Index multiplied by the percentage passing the 0.075 mm sieve.

Figure 2 Chart of Plasticity Product against Coarseness Index



A:	Good performance under wet and dry conditions
B	Good performance under wet conditions; corrugates in dry conditions
C	Lacks cohesion: rapid deterioration with trafiic
D	Good in dry conditions; slippery in wet; potholes/erosion
E	Poor in both wet and dry conditions
F	Too coarse: erodes badly; difficult to maintain
G	Too fine; trafficability problems in wet and very dusty when dry

The Ic and PP values the 2008 and 2009 gravel samples on Samphan Road are shown in Table 11, with a letter in the final column to indicate the region of the chart where each sample would be placed.
All of the samples are on the right hand side of the chart. Most of them, marked with F+, are even to the right of region F. Most of the gravel is therefore at high risk of erosion with maintenance difficulties ahead.

However, it is worth noting that material complying with the contract specification, with an Ic of 35% and a PI of 12% and 15% passing 0.075 mm, giving a PP of 180 would be well located on the horizontal axis but significantly below the preferred region of the chart (Region A since the road must endure wet and dry seasons) and therefore at risk of looseness, corrugations, erosion, etc when dry.

Table 11 Ic-PP Values of Sampled Gravels

Gravel approval testing in 2008			**Combined testing**		
		Chainage	Ic *	PP	
Borrow pits		1650	92	164	F+
		16200	72	102	F+
		21000 (1)	91	210	F+
		21000 (2)	90	190	F+
		21000 (mix)	91	166	F+
		26150	92	109	F+
		35200	92	123	F+
		37400	89	148	F+
		45100	93	29	F+

Gravel testing in 2009			**Combined testing**		
		Chainage	Ic *	PP	
Test pits	TP01	100	63	597	F
	TP02	250	56	443	A
	TP03	1250	58	326	B
	TP04	1400	69	168	F
	TP05	1550	54	623	A
	TP06	1700	82	86	F+
	TP07	1850	71	272	F+
	TP08	1980	72	236	F+
	TP09	2100	76	175	F+
	TP10	2460	55	395	B
Borrow pits	BP01	3400	81	45	F+
	BP02	12600	62	571	F
	BP03	24700	64	428	F
	BP04	48800	73	432	F+

5.5 Conclusions on gravel tests

The following conclusions relate to the assessment of gravel:

- The gravel type is not as required in the specification
- The soaked gravel strength generally meets the specification
- Density tests and observation suggest that the required density to mobilise the soaked strength has been achieved
- Most of the gravel samples tested in 2008 and 2009 do not meet the grading and plasticity specifications
- In many of the tests there appears to be a significant difference between one series and another, perhaps indicating either poor sampling practice or poor laboratory reproducability
- The standard Ic-PP plots indicate the gravel is likely to be very prone to erosion
- The gravel layer is significantly thinner than specification

5.6 Subgrade compliance

Table 12 shows, for each trial section and sub-section, the subgrade strength was derived from the DCP and soaked CBR testing in 2008 and used in the design of the spot improvements, the in situ strengths at a depth of 250 mm , as described in 4.3 above and assumed to be representative of the subgrade, and the specified soaked strength at this depth. The table also assesses whether or not the subgrade meets the contract specification and whether or not the subgrade meets the assumed subgrade design strength.

Table 12 Subgrade strengths

Chainage		Subgrade design strength 2008 (%)	Subgrade strength from 2009 DCP tests (%)		Contract specification	Meets specification?	Adequate for designed improvements?
From	To		Ave	Min			
0+000	0+350	>7	25	11	8%	Yes	Yes
1+200	1+400	7 – 10.9	25	10	8%	Yes	Yes
1+400	1+700	> 11	30	12	8%	Yes	Yes
1+700	1+865	7 – 10.9	30	12	8%	Yes	Yes
1+950	2+025	4 – 6.9	23	10	8%	Yes	Yes
2+025	2+100	> 11	38	13	8%	Yes	Yes
2+400	2+520	4 – 6.9	35	8	8%	Yes	Yes

Assuming that the strengths estimated from DCP tests are a reliable indicator of the soaked CBR strengths, the subgrade of all trial sections and sub-sections meets the specification. In general subgrade strength is not a significant concern along Samphan Road.

6 Rapid condition surveys

6.1 Objectives

A series of rapid condition survey methods were trialled along the entire road, each with the objective of making an initial identification of the sites where further improvements are appropriate and possibly also identifying major defects along the remainder of the road.

6.2 Accuracy of chainage and elevation measurements

Elevations measured with the GPS were observed to fluctuate by up to 50 metres over a period of a few hours, with a gradual drift rather than sudden change. The following explanation was received from Garmin, the supplier: "The GPSMap 60CSx has a barometric altimeter, meaning that it calculates altitude using pressure change. When calibrated, this is more accurate than GPS altitude which is said to be less than 25 metres (95% of the time). This barometric altimeter can be affected by changing weather, i.e. pressure, and so the gradual change will have been caused by a pressure trend. It is possible to set the barometer to be calibrated by the GPS. However, it would be more accurate to self-calibrate the GPS at regular intervals when in changing conditions."

With this explanation, it is felt that estimates of elevation and gradient made over a short period of time will be sufficiently accurate for the objectives of the survey, particularly in hilly terrain where gradual drift in elevation is less significant than it would be in flatter terrain.

The use of a hand level has been discussed above, with the conclusion that it is an accurate and useful instrument for these condition surveys, although it needs two surveyors and can be time consuming if used for the entire length of road. An automatic level, staff and tripod is the most accurate but its use is too slow for a rapid condition survey. Visual estimation is extremely unreliable, often unable to identify whether a section in hilly terrain is uphill or downhill. Surveying a road in rain is useful as the direction of surface run off can be easily seen.

Regarding chainage measurement, trip meters vary from car to car, by perhaps up to 5%, very significant when roads longer than 10 kilometres are being surveyed. GPS odometers are likely to be accurate if carried along the centre lines of a road but since all horizontal movement is aggregated, they do not permit the surveyor to deviate from or even reverse along the centre line of the road. It is probable the entire road was set out using a long tape measure – a stake observed in approximately its correct position at 38+200 would suggest so – but such setting out is unlikely to be available or appropriate to a survey of a route yet to be improved. Kilometre posts are being erected along Samphan Road but were seen to be very approximately located, probably using the trip meter of a contractor's vehicle.

6.3 Comparison of different survey methods

The following paragraphs briefly compare the visual condition survey and the 4 trialled rapid condition survey methods and make some initial comments on the selection of appropriate survey methods.

Visual condition survey: This survey method can be used to survey very approximately 1 kilometre per day. The road is assessed in 5 metre blocks and the survey method is useful for monitoring a section over time and identifying gradual and specific changes in rutting, erosion and other aspects.

Rapid survey in 50 metre sections: Table 13 shows initial results from this survey method. It was used for the first 10 km of the road, with chainages taken from markers set out with a long tape measure in advance of the survey. The method can survey approximately 5 kilometres per day.

For a method such as this, it is important to have simple and clear definitions of the different ratings used. It is less precise but quicker than the visual condition survey. It is useful for getting good coverage of a road and an overall indication of condition but is not accurate enough to be used as part of a chronological series of monitoring surveys.

Rapid survey recording terrain and gradient: This method recorded the chainages, measured using the GPS odometer, where lateral terrain, gradient changed or where villages started and ended. The method was used from 10 kilometres to 20 kilometres along the road and can survey approximately 15 kilometres per day, although this rate could increase if less time is spent assessing specific defects along the road. No form was used, just a series of chainages in a note book.

Rapid survey recording chainage and elevation: This method recorded only the chainage and elevation, measured with the GPS, of specific locations along the road. This method was used for the final 32 kilometres of the road and can survey approximately 30 kilometres per day. No form was used, just a series of chainages and elevations. The emphasis of the survey is to record sufficient detail to describe the overall layout of the road as rapidly as possible. As with any foot survey, the closer contact that is possible than with a car survey and the greater facility to stop, allows more detail to be collected and a stronger impression to be gained, although a target rate of 30 kilometres per day does not give much opportunity for stopping. As above, using a GPS for chainage does not allow the surveyor to deviate from walking forwards along the centre line.

Table 13 Rapid condition survey results

Gradient		General - numbers are used in association with all features	
+	up	1	mild, gentle, low risk
-	down	2	
0	flat	3	
1	gentle	4	
2	steep	5	severe, bad condition, high risk
3	v steep		

From	Gradient	L Slope	L Drain	L Shoulder	Gravel	Shape	Surface	R Shoulder	R Drain	R Slope	Notes
				good join with main road although maybe a problem with drainage							0-0.35 gravelled after survey
0	+2	up, steep, 1	erosion, 2	loose, steep	large agg.	good	good	breaking	-	houses	breaking: edge break of unstable shoulder
50	+1	up, steep, 1	erosion, 1	OK	large agg.	good	good	breaking, 3	-	houses	
100	+1	up, steep, 1	sediment, 3	OK	large agg.	good	good	breaking, 2	-	houses	
					hard, dusty						
150	+1	up, steep, 1	sediment	OK	good	good	good	breaking, 1	-	down, 1	
			not draining								
200	-1	up, steep, 1	sediment	OK	good	good	good	breaking, 1	-	-	
			not draining								
250	-1	up, steep, 1	sediment	OK	good	OK	good	OK	-	down, 1	
			filling								
300	0	up, steep, 1	filling up	OK	good	OK	good	OK	shallow	steep down	drain needs maintenance
			needs mt							erosion risk	
		culvert @ 340 - low headwalls and wingwalls, high risk of erosion, poorly backfilled									
350	+1	up, steep	blocking	OK	good	OK	good	OK	-	down	
		small slips									
400	+2	up, steep, 1	OK	OK	good	OK	good	breaking, 1	OK	steep down, 3	
450	+1	steep up rock	OK	OK	good	OK	good	loose	OK	steep down, 2	
500	-1	up, steep, 1	OK	OK loose	good	OK	good	loose	-	steep down, 4	
550	+1	up, steep, 1	OK	loose	good	OK	good	loose	-	steep down, 4	
		culvert @ 585 similar to earlier culvert, erosion at outfall, poorly backfilled									
600	+2	up, steep, 1	sediment	loose	good	OK	good	loose	-	steep down, 4	
650	+2	up, steep, 1	sediment, OK	OK	good	OK	good	loose	-	steep down, 2	
700	+2	up, steep, 1	OK	OK	good	OK	good	OK	OK	steep down, 2	
750	+1	up, steep, 1	OK	OK	good	OK	good	OK, loose	not well	steep down, 3	
									formed		
800	+1	up, steep, 1	OK	OK, loose	good	OK	good	loose	not well	down, 2	
									formed		
									wide verge		
850	0	steep up	OK	OK	good	OK	good	OK loose	not well	steep down, 1	
		1 small slip							formed		
									wide verge		
900	-1	steep up	OK	loose	good	OK	good	OK loose	OK	steep down, 1	
		col 940-975 down on both sides of the road									
950	+2	up, steep, 1	sediment OK	OK	good	OK	good	loose	loose	steep down, 2	
									stones		
1000	+2	up, steep,1	OK, bed rock	OK loose	large agg	OK	good	loose	loose	steep down, 2	
					good				stones		
1050	+2	up, steep, 1	OK, bedrock	OK loose	good	OK	good	loose	not well	steep down, 2	
									formed		
1100	+2	up, steep, 1	OK	OK	good	OK	good	loose	not well	steep down, 2	
									formed		

Rapid survey by vehicle: All participants carried out a rapid condition survey in 3 separate vehicles, driving 52 kilometres in approximately 3 hours. The survey method is an easy way of covering many kilometres but the loss of contact with the road allows no more than superficial information and impression to be gathered. No form was used, just a series of chainages and condition summaries.

6.4 Conclusion on survey methods

From these different survey methods, it should be possible to establish a rapid condition survey method that is suitable for assessing overall condition and specific defects, and that is quicker but less detailed than the visual condition survey. A form should be used with simple codes for, in most cases, different features performing well, starting to fail, or failed. The form should allow the road to be divided into sections of either constant length, no more than 50 metres long, or uniform condition and variable length. The form should include lateral terrain (cut, sidelong, embanked or flat), and the condition of side slopes, drains, shoulders and carriageway, and room for additional remarks with prompts as to items to consider – tight curves, villages, etc. This description is similar to the Rapid Survey Form included in the manual written under SEACAP 3.02.

Since chainage markers allow a surveyor more freedom to walk a site, chainage markers should be set up in advance if possible.. A GPS should be used for measuring elevation, although a hand level should also be used at specific sites and to check GPS measurements.

The selected survey method should suit the following aspects of the survey:

- The available means of transport
- The available time
- The length of the road
- The necessary focus of the survey – gradient, flood risk, population centres, etc
- The likelihood of future opportunities to carry out more surveys
- The season when the survey is to be carried out, specifically the timing of the rains

6.5 Rapid condition survey results

Through the different surveys in 2008 and 2009, the chainage and elevation of the entire road were measured. Since Samphan Road is in hilly terrain and spot improvements are likely to be selected primarily to protect and improve steep sections, these measurements have been processed in a spreadsheet into gradients and plotted as a longitudinal profile of the road. Figure 3 shows the longitudinal profile of the road, with kilometres on the horizontal axis and metres on the vertical axis..

In some cases a longitudinal profile may be able to identify the steepest sections, or at least the areas of the road to survey in more detail. However, all that the profile can do in this case is to show that Samphan Road is hilly along its entire length.

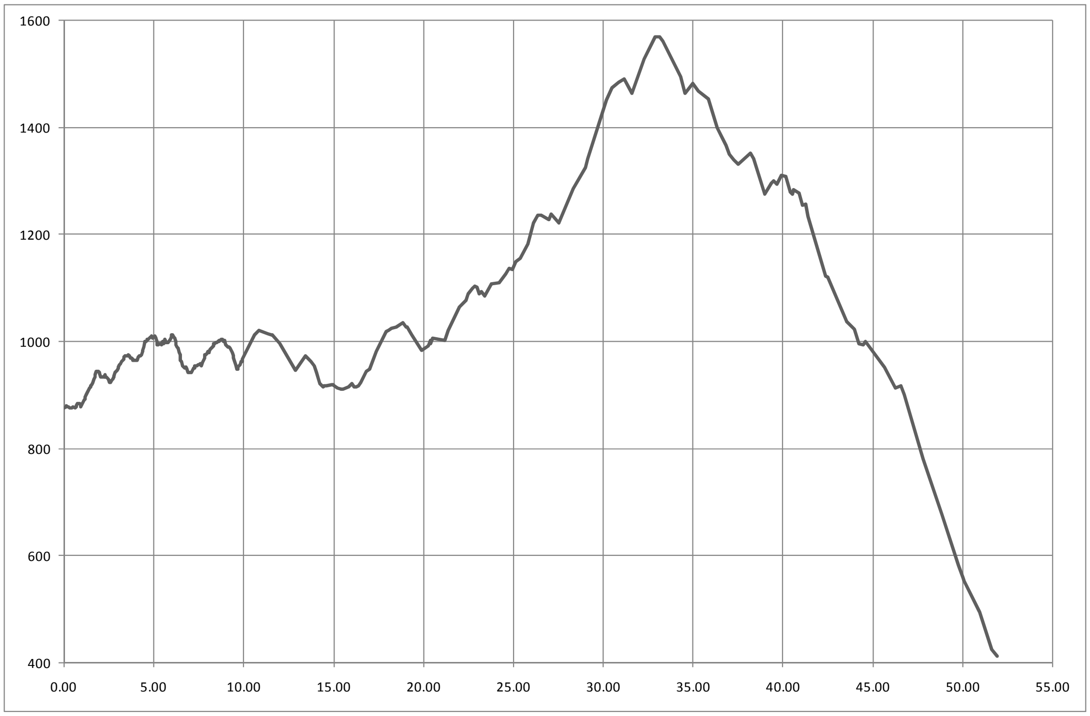


Figure 3 Longitudinal profile of Samphan road

It will be necessary to resurvey the road if funds for further improvements become available, but the rapid condition surveys have given a useful indication of the overall condition of the road and the location and type of improvements that will probably be required. The sections where the resurvey should initially focus, beyond the first 5 kilometres, are given in Table 14

Table 14Samphan Road Sections to be Surveyed for Spot Improvements

5+750 – 7+000
7+500 – 7+800
8+250 – 8+800
9+200 – 10+700
13+750 – 14+500
20+500 – 22+400
24+500 – 30+500
31+000 – 32+500
33+300 – end of road

7 General Observations and Conclusions

7.1 Alignment

The alignment of Samphan Road is good, for most of its length being slightly below the ridge line and linking col to col, resulting in much fewer drainage problems than if the road has been lower in a valley, no large or permanent water crossings, apart from one close to Samphan, where the road drops down to river level across a hillside. One short section, approximately 38 kilometres from Pheejermai, has been realigned in order to reduce the length of construction, after agreement with local parties. Most horizontal and vertical curves do not pose any danger, although some curves and crests are unavoidably tight, as always occurs in hilly terrain.

Almost the entire road is located on a steep side slope, with short sections along the top of ridges or through cols. It appears that the road is formed on the cut surface rather than on a balanced cut and fill section, with visual intersection of slopes and carriageway, discussion with the LSRSP site supervisor and DCP results, as discussed above, supporting this, although it is possible that the shoulder of the road is directly above the outside edge of the cut surface, putting the carriageway at risk of failure if the slope below the road erodes or slips.

Long lengths of road with this lateral cross section are liable to collect large volumes of water in the uphill side drain.

7.2 Traffic

The main conclusions are

- There currently a very low level of traffic.
- There is reduced traffic level as distance from Pheejermai increases,
- There is a likelihood of rapid increase in traffic with the risk of trucks larger than the design vehicle using the road,
- There is a high proportion of motorbikes currently using the road.

7.3 Gravel surface

The gravel surface was observed to be of reasonable quality and well compacted into a tight and strong surface, but liable to form dust and erode in dry and wet weather respectively. In some areas the proportion of fines was felt to be low and in others, aggregate up to 150 mm across was seen in some areas. Where large aggregate is present, as the smaller particles wear away, an extremely rough surface will result.

It was reported by the LSRSP supervisor that large aggregates were expected to be crushed by the roller, but that with one gravel source this did not happen and so use of the source was ceased. Gravel does not appear to be stockpiled and mixed before use, partly due to the lack of room alongside the road, which can result in variable grading from site to site. Some areas of gravel above culverts appeared to be very plastic and prone to cracking, presumably because a poor material source was used for backfilling instead of an approved gravel source.

The gravel is all non-lateritic material largely derived from the in situ weathering of the bedrock of variable sandstone, siltstone or shale. All sources are alongside the road, although most of the hillsides are said to be gravel with a depth of 20-50 metres. Two distinct types of weathered rock gravel were seen, differentiated as grey and red. The grey is used where possible, with the red being too soft. A brown gravel is also used but to a lesser extent.

7.4 Carriageway

The camber of the gravel surface is clearly inadequate in many places. The specified camber is 5% but even if this is achieved during construction, it is likely to rapidly fall to 3-4% which is not sufficient to prevent longitudinal erosion in the wheeltracks, as indeed was observed in several locations, despite the annual rains having not yet started.

Superelevation is sometimes formed where it is not needed. Discussion with the LSRSP supervisors indicates that the road surface was not set out, the camber being left, in most cases, for the grader operator to form using sight and previous experience.

The gravel surface appears hard and well compacted, although, similarly to camber formation by the grader operator, compaction appears to be left to the roller operator to achieve, typically with a standard number of passes, six in this case.

The surface in a longitudinal direction is reasonably good, with vehicle speeds of up to 70 km/h being comfortable when road curvature permits, although the surface is likely to become rougher as gravel wears out and large stones are exposed.

The carriageway width appeared to be adequate for current use of the road, although it is at risk of rapid reduction as the unstable shoulders deteriorate.

7.5 Shoulders

Although the gravel carriageway is normally well compacted into a tight and strong surface, the shoulders are mostly segregated and poorly compacted. The shoulders are presumably segregated due to the gravel having oversized aggregate and a low proportion of fines and being spread laterally by the grader, and they are presumably poorly compacted because of roller operators not being confident when working on a camber close to a steep drop, a presumption supported by the outside shoulder typically being less well compacted than the inside shoulder. As a result of segregation and poor compaction, the shoulders are weak, as shown by frequent wheeltracks, unstable and at risk of collapse under traffic or run off, with a consequent loss of carriageway width.

7.6 Verges

At some locations there is a verge on the outside of the road, up to 5 metres wide, typically where the road curves sharply back towards the hillside around an inclined ridge. These verges may be formed on a cut surface or from loose dumped material. They are typically unformed and uncompacted with no drainage and no cross fall. They are liable to saturate in the rainy season and weaken and possibly slip. These verges should be lightly compacted and shallow surface drains should be provided to prevent saturation.

7.7 Side drains

Side drains are provided on the uphill side of the road, but not on the downhill side, although they could be provided when a wide verge is present. The drains are V-shaped with, in some cases, steep inner and outer slopes. Some side drains are cut into rock and on some steep sections if erosion is expected are lined with wet masonry. The drain lining is generally well constructed although there are already signs of the gravel surface wearing down below the edge of the lining and water flowing under the lining, a defect that must be corrected if the lining is not to be undercut and collapse. Scour checks were not seen in the side drains, but should be considered after the effects of the first rain are seen.

The uphill side drains collect water from the carriageway and run off from land above the road. On long inclined sections the side drains are likely to collect large volumes of water. They should be widened where this might happen and means to relieve the water flow are required.

Very few mitre drains are seen on Samphan Road, although this is, in most cases, because the steep slopes above the road do not permit them. They should be provided wherever possible and their outfalls should be protected against erosion. If mitre drains cannot be provided on long inclined sections, relief culverts should be considered.

7.8 Culverts

Because the road is just below the ridge line for most of its length, there are very few water courses to cross, most of the surface water entering the side drains as sheet run off rather than in a channel. Most culverts are located at saddles or low points in the road to prevent water ponding and flooding the surface. Initial inspection indicates that culverts are provided at most, if not all, low points. Some culverts are located as relief culverts on long inclined sections, although more are probably required.

Almost all inlet structures are drop inlets. Almost all culverts have a single concrete pipe with a diameter of around 600 mm, although the Bill of Quantities indicates that a quarter of culverts are 800 or 1000 mm in diameter. Despite this contractual variation, the absence of any double culverts in 52 kilometres of hilly terrain in a wet region indicates that culverts may not have been hydraulically designed in detail. The constructed culverts were not counted but the number in the BoQ indicates one culvert every 570 metres. All culvert outlets are standard outlets with wingwalls and apron. The box culvert, believed to be near the end of the road at Samphan where the road drops down to river level, was not observed.

The headwalls and wingwalls of the inlets and outlets appear too low, often 300 mm or more below the level that they should be at if the surface and slopes are not to erode or just collapse over the headwalls and windwalls. The outlets are often located above steep slopes in the middle of loose dumped material, with no protection below the apron and in most cases with no formed outfall channel, despite flowing past houses in a village, onto bare slopes or through farm land. These outfall channels are already eroding, with the risk of erosion retreating into the road structure, and aprons and wingwalls are already cracking and it is expected that the road structure will deteriorate rapidly due to the into the inlet and outlet structures.

The headwalls and wingwalls should be raised, outfall channels formed and protected and vegetation encouraged wherever possible to prevent erosion and collapse.

Some culverts appear to have been backfilled with a plastic material, prone to cracking instead of gravel from an approved source.

7.9 Earthworks

Most of the road is constructed under a steep up slope, formed in rock, or weathered rock. These slopes are often steeper than the limits in the specification, especially when composed of unconsolidated gravel or clay, and are not benched. They currently appear to be stable, although this may not be the case in the rains or as the clay dries out. Indeed when the road was first visited in 2008, there were a large number of up slope failures , and this before the slopes were increased during the second phase of excavation. It is therefore probable that many slips will occur during the 2009 rains, blocking drains and causing overtopping and surface erosion if not immediately cleared. Ideally the up slopes should be reduced, although this is very difficult and costly to do when the hillside is high and steep. Vegetation should be planted on all bare slopes where practical and maintenance should be both regular and reactive.

Most of the down slopes along the road are covered in loose dumped material, typically for 10-20 metres below the road, contravening the specification. This material is already eroding and showing clear signs of imminent slippage, both of which can retreat into the road structure reducing the carriageway width and putting road users at risk, where the previously vegetated original slope would not have done. The loose material may also erode or slip onto farmland or into villages or water sources. This material should be cleared or triggered with small slips to spread the material more thinly, although it is unlikely that this will happen. It is hoped that the slopes will vegetate themselves from the underlying plants over the next two years, but this could be encouraged in order to reduce the period during which the slopes are at risk. Large areas of farmland alongside the road are currently being burned and cleared for agriculture, but in the process these slopes are being placed at greater risk of erosion.

The practice of excavating carriageway materials from adjacent cut-lopes should not be permitted, Plate 4. It leaves behind over-steep slopes that have high risk of failure and the potential to block the carriageway. Contractually this practice contravenes the requirements on earthwork slopes.

7.10 Focus of spot improvements

Despite other defects and concerns such as low culvert headwalls and earthwork failures slipping onto the road the main concern regarding the long term future of Samphan Road centres on gradient and the effects of the hills, including longitudinal erosion and surface deterioration, loss of traction and occasional slipperiness and overtopping of side drains on long descents. For this reason, unsurprisingly, the next stage of improvement works must focus on pavements and surfaces, but must not ignore drain lining, culvert improvements, slope protection, drainage capacity and so on. It is noted that, from the results of the rapid condition surveys, a total of 20-25 kilometres – almost half the road – is 6% or steeper; the cost of this length of surfacing and associated improvements will be extremely high.

When these sites are being prioritised for improvement, it is recommended that the guidance in the EOD Manual for single entry roads is followed, whereby the sites are improved starting from those nearest to Pheejermai and working towards Samphan until funds are finished, this being the same manner in which the improvements between Pheerjermai and Pheejerkao were prioritised in 2008.

When spot improvements were selected in 2008, steep hills and villages were prioritised for improvement. It is now clear that improvement of hills is vital for the medium term and even short term survival of the road, while the reduction of dust through villages and improved appearance, although two very significant social benefits, must be seen as secondary to securing the future of the road. Further to this, few of the villages are on straight and flat sections of the road where speeds may be high and dust a major problem. If funds permit after surfaces, culverts, side drains and slopes have been improved, concrete or bituminous surfaces through villages should be considered, with some basic traffic calming measures.

7.11 Safety measures

A variety of safety measures may be appropriate along Samphan Road, although specific rural road safety guidance should be consulted before decisions are made. These might include traffic calming – road humps, narrowed entrances – in villages and near schools, warning signs and separate footpaths where land is available. The foundations of the guide posts, which were being installed at the time of the site work, should be checked since some of them appeared to be founded in loose material close to the down slope.

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7.12 Future maintenance

It is vital that Samphan Road is well maintained, particularly during and immediately after the first rainy season, when vegetation is still growing on the bare slopes and shoulders and when many construction defects first become evident. Camber maintenance, drainage repairs and emergency clearance of up slope slips are perhaps the most important maintenance activities. It is equally vital that DPWT Phongsali staff ensure that the contractor fulfils all obligations under the contract maintenance period. It is probable that long term maintenance of Samphan Road will be costly. As part of the maintenance programme, a detailed inspection after the 2009 rains will be extremely useful, in order to identify construction defects, the urgency of any improvements and the highest priority locations for the next stage of improvement works.

8 Assessment of objectives

8.1 Trial sections: detailed survey & comparison with specifications and designs

The detailed surveys progressed well, with very thorough data collection by the SEACAP and Phongsali teams. The results allowed comparisons to be made with the contract specifications and with the assumptions behind the designs of the spot improvements.

8.2 Rapid condition survey of remainder of road

A variety of rapid condition survey methods were used. The results identified the overall condition of the road and the location and type of improvements that will probably be required, although it will be necessary to resurvey the road in more detail if funds for further improvements become available. Ideas have been discussed regarding the preferred rapid condition survey method, although this method must always be adjusted to suit the objective and focus of the survey and the available resources.

8.3 Training of DPWT Phongsali staff

Most of the DPWT Phongsali staff had used the DCP during the second workshop in 2008. However, this was the first time that they carried out detailed surveys using a variety of equipment and methods. They said that they felt that they had learned well and gained good experience. At the end of the week it was stressed to them that the survey methods they have used are some of many. They must always consider the specific requirements of a survey, whether it is for rapid assessment, long term monitoring, design validation or contract supervision, and choose the surveys that are appropriate for their needs, rather than simply repeating what they may see as standard tests.

Plate 1. Spot improvement section. Climbing curve at km 2.000

Plate 2. Heavy contractor plant on the Samphan road. One big advantage of the delay in building the spot improvements will be the decreased risk of heavy plant using the trial surfaces

Plate 3 Coarse out-of specification wearing course materials evident in this section

Plate 4 Over-steepening of cut-slopes in order to obtain out-of specification gravel using heavy trucks.

Plate 5 Tension cracks evident in failing materials dumped below road

Plate 6 Poor compaction in shoulders evidenced by ruts and tyre marks