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Objectives

- SEACAP 17 aims to support the basic SEACAP requirements of promoting the uptake of low cost, sustainable solutions for rural access across South East Asia.

- Specifically, SEACAP 17 aspires to identify suitable cost-effective methods of improving all-year access to the rural poor through low-cost locally resource based improvement of problematic lengths of road resulting in sustainable rural access roads.

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- Establish Appropriate Solutions
  - Improve methods of road construction
  - Improve all year access to rural poor
  - Utilise low-cost local resource-based methods
  - Identify cost effective community based methods
  - Introduce previously trialled surfaces under SEACAP to Lao (PDR)

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- Project Location

Project Area

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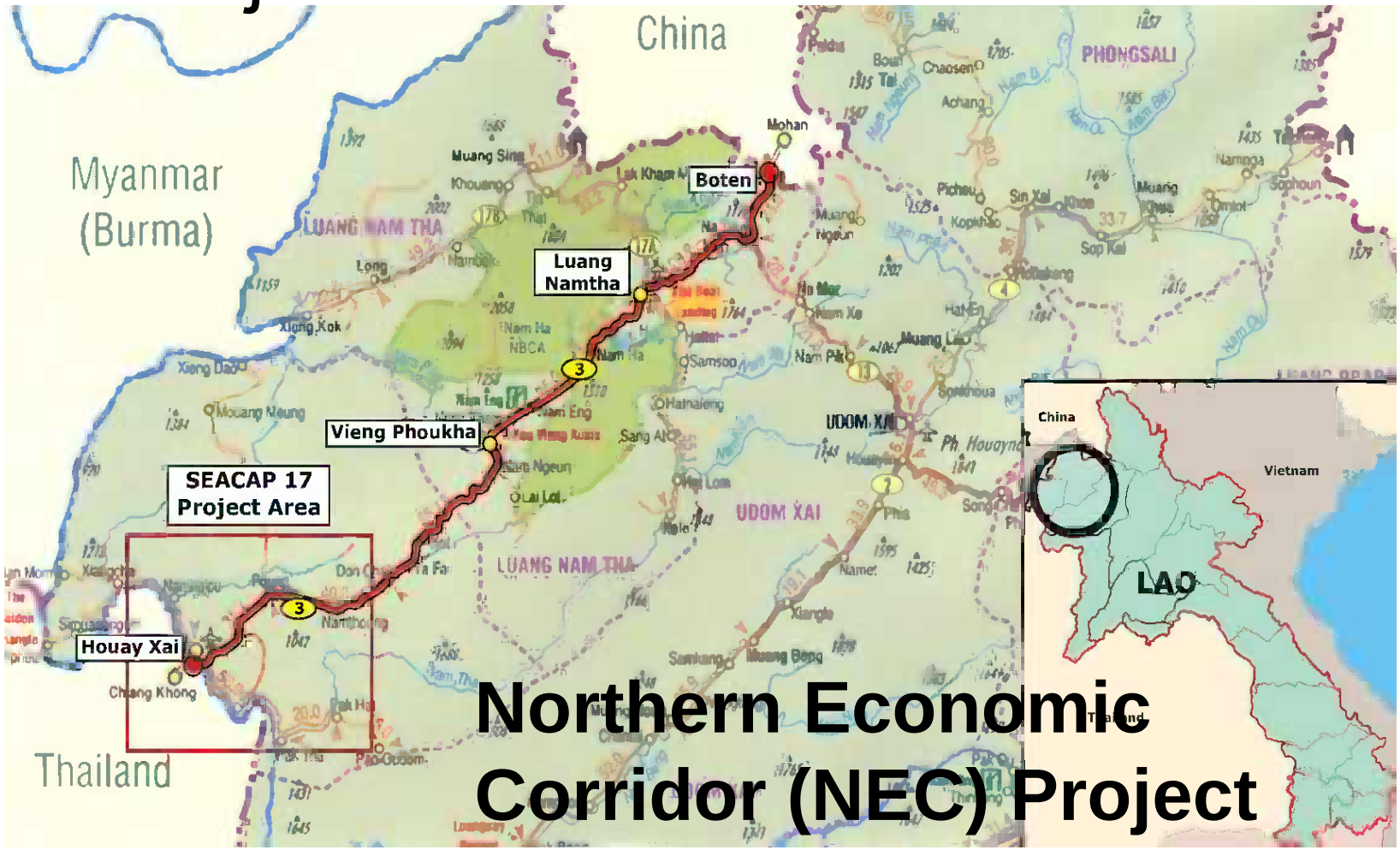
- Project Location



Northern Economic Corridor (NEC) Project

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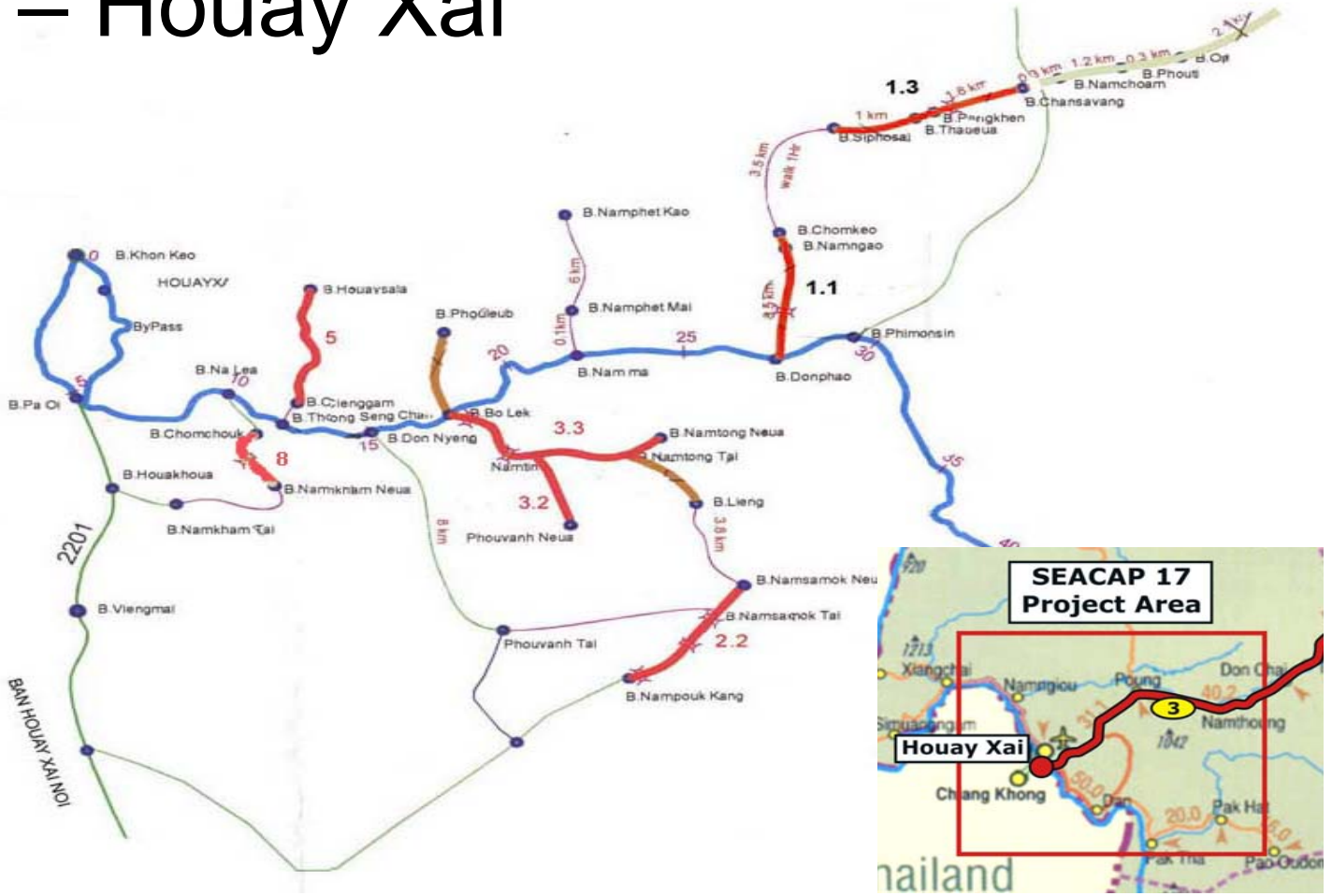
- Improve Access Roads
  - Houay Xai



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- MPWT/ DFID/ ADB Collaboration
  - Activities Funded by SEACAP (DFID)
    - Technical assistance for managing and supervising the SEACAP access roads on specifically identified access roads of Route 3
  - Activities funded by MPWT/ ADB
    - Cost of civil works associated with the selected access roads in addition to the Route 3 construction costs

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- The research was implemented in four modules:

Module 1: Project Planning & Initiation

Module 2: Management & Data Capture

Module 3: Data Interpretation

Module 4: Information Dissemination

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➢ Basic Approach

- ➢ To replace standard NEC gravel pavement with SEACAP trial pavements at specific locations along the selected access roads
- ➢ Pavement types selected for the trials were taken from those presented at the Knowledge Exchange Workshop in Vientiane in December 2004
- ➢ The specifications for each of the trial pavements were developed from similar projects in the region (SEACAP 1 Vietnam) and worldwide

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➢1. Standard NEC Gravel Road

This construction comprises 200 mm of gravel wearing course with a bearing capacity of CBR≥25% constructed on a selected subgrade layer of 300 mm thickness with a bearing capacity of CBR≥8% constructed on a design subgrade CBR≥5% in cut

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- 1. Standard NEC Gravel Road

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➢2. Bamboo Reinforced Concrete

A bamboo reinforced surface consists of a layer of concrete, reinforced with strips of bamboo, and laid upon a compacted base

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- 2. Bamboo Reinforced Concrete

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- 2. Bamboo Reinforced Concrete

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➢3. Otta Seal (single and double)

This surface comprises of a layer of binder followed by a layer of aggregate that is rolled into the binder using a roller or loaded trucks. It is different to surface dressing in that an 'all in' graded gravel or crushed aggregate is used instead of single sized chippings

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- 3. Otta Seal (single and double)

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- 3. Otta Seal (single and double)

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➢4. Geocell Pavement

This comprises manufactured plastic formwork is used to construct in-situ concrete paving. The plastic formwork is sacrificial and remains embedded in the concrete

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- 4. Geocell Pavement

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- 4. Geocell Pavement

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➢5. Hand Packed Stone

This surface consists of a layer of large stones between which smaller chips are packed. Remaining voids are filled with sand or gravel to form a strong and semi-impervious matrix

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- 5. Hand Packed Stone

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- 5. Hand Packed Stone

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➢6. Mortared Stone

This surface consists of a layer of large stones, placed closely together to form a tight surface. The voids are filled with mortar to form an impervious layer

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- 6. Mortared Stone

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- 6. Mortared Stone

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➢7. Concrete Paving Blocks

The blocks are precast in moulds and then laid side by side on the road, gaps between blocks are filled with fine material to form a strong and semi-impervious layer

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- 7. Concrete Paving Blocks

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- 7. Concrete Paving Blocks

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➢8. Sand Seal

This seal consisting of a machine applied film of bitumen followed by the application of excess sand which is lightly rolled into the bitumen

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- 8. Sand Seal

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- 8. Sand Seal

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➢9. Engineered Natural Surface

This construction is used where the existing subgrade material comprises natural gravel with good quality characteristics

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- 9. Engineered Natural Surface

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- Construction Issues
  - Training of the Contractor
    - There was a training section (20-100m) before each trial sections was constructed
    - The contractor's staff had insufficient skills to benefit properly from the training given
    - Language and clear communications were difficult

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- Construction Issues
  - Appropriate Specifications
    - Some common specifications were found to be inappropriate when applied in Lao. For example, the shape of hand knapped stone
    - Small scale contractors have expertise in local construction techniques but require considerable help when using non-standard techniques

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- Construction Issues
  - Research/ Construction Interface
    - When a research improvement was identified during the project we were unable to pursue it due to contractual funding constraints
    - Contractors should be encouraged to use local labour in order that the expertise is not lost in the country
    - Our power as supervisor does not permit us to force the contractor to rectify poor work

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➢Construction Costs

	Pavement Description		Cost/m² (USD)
1	Hand Packed stone		6.33
2	Mortared Stone		6.33
3	Sand Seal		6.27
4	Single Otta Seal and Sand Cover		8.07
5	Double Otta Seal		9.10
6	Bamboo Reinforced Concrete	125 mm	15.22
7	Bamboo Reinforced Concrete	150 mm	17.74
8	Concrete Paving Block		29.60
9	Geocell Concrete Pavement	75 mm	18.83
10	Geocell Concrete Pavement	100 mm	23.46
11	Geocell Concrete Pavement	150 mm	32.73
12	NEC Standard Gravel Control		2.43
13	Engineered Natural Surface		0.00

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➢Construction Costs

- The cost per square metre is the cost of the designated pavement construction above the prepared subgrade.
- On this basis the cost of Engineered Natural Surface is nil since this is, effectively, the prepared subgrade in an area where the in situ material is of a high enough quality to act as the road pavement/ surface
- These results must be viewed with caution since they are based on just one Contractor's view of the costs.
- Although the Whole Life Cost rankings change somewhat depending on whether a 6% or 10% discount rate is adopted the overall pattern is much the same with only minor differences.

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➢Construction Costs

Examination of the construction costs for each pavement type indicates two obvious irregularities:

- The cost of a 150 mm Geocell concrete pavement is almost double that of a 150 mm Reinforced Bamboo concrete pavement although the cost of 150 mm Geocell form material is only USD 6/m² against which must be set the cost of providing the bamboo reinforcement and the edge formwork required for the Bamboo Reinforced pavement.
- The cost of plain Concrete Block paving is also remarkably high, particularly when compared with the costs of Hand Packed or Mortared Stone pavement (USD 6.328/m²). Even allowing for the cost of concrete it would appear that concrete block paving, which is simpler to lay than the Stone pavements, should have cost no more than USD 14.15/m² at the very most.

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➢Whole Life Costs

Pavement Type Ordered using 6% Discount Rate	USD/m²	
	Constr	NPV
Mortared Stone	6.33	5.58
Handpacked Stone	6.33	6.17
Engineered Natural Material - Level	0.23	8.06
Standard NEC Gravel - Straight and Level	2.43	10.14
Double Otta Seal	9.10	10.81
Engineered Natural Material - Hilly	0.23	11.82
Concrete Paving Blocks	14.15	12.20
Bamboo Reinforced Concrete 125mm	15.22	12.98
Standard NEC Gravel - Hilly	2.43	13.90
Bamboo Reinforced Concrete 150mm	17.74	14.46
Sand Seal	6.27	15.75
Single Otta Seal with Sand Seal	7.69	16.50
Geocells 75mm	18.83	17.12
Geocells 100mm	23.46	20.23
Geocells 150mm	32.73	26.69

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➢Whole Life Costs

Pavement Type Ordered using 10% Discount Rate	USD/m²	
	Constr	NPV
Mortared Stone	6.33	5.68
Engineered Natural Material - Level	0.23	5.91
Handpacked Stone	6.33	6.00
Standard NEC Gravel - Straight and Level	2.43	7.91
Engineered Natural Material - Hilly	0.23	8.60
Double Otta Seal	9.10	9.81
Standard NEC Gravel - Hilly	2.43	10.60
Sand Seal	6.27	12.38
Concrete Paving Blocks	14.15	12.53
Single Otta Seal with Sand Seal	7.69	13.16
Bamboo Reinforced Concrete 125mm	15.22	13.39
Bamboo Reinforced Concrete 150mm	17.74	15.27
Geocells 75mm	18.83	17.15
Geocells 100mm	23.46	20.78
Geocells 150mm	32.73	28.18

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- Monitoring
  - Visual inspection surface condition logging
  - Photographic recording
  - Surface deformation recording (dipped levels and rut measurement)
  - Surface roughness using a MERLIN apparatus
  - Surface texture (sand patch test)
  - Classified traffic counts
  - Structural integrity using a Dynatest 3031 LWD Light Weight Deflectometer

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➢Conclusions - General

- Owing to the long term nature of this project there are only limited conclusions to be drawn at this intermediate stage.
- The design process has shown the need for experienced engineers to spend some time in the field understanding the particular problems of the route(s) and exploring the various possible solutions. Solutions adopted should take account of both local materials and any available local skills.
- The construction process has provided data regarding the cost of constructing various types of alternative pavement and the problems which may be found in their construction. It has also highlighted the problems which can be encountered when trying to implement a research operation on the back of a regular commercial construction contract.

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➢Conclusions - General

- Clearly, further monitoring work is required to assess the long-term performance of the SEACAP 17 trial pavements against time in order that a detailed cost against longevity/deterioration model can be defined. Only when their success over the long term has been clearly demonstrated, will these techniques be accepted by general practitioners and the recommendations of this work become acceptable practice and mainstreamed.
- It is concluded that the successes and failures from this project, and other similar projects, cannot simply be applied elsewhere. While note should be take of the materials and methods of construction reported here, a detailed investigation must be conducted in the particular region where work is proposed.

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➢Conclusions - General

- Cost data shows, unsurprisingly, that improved pavements cost more. Accordingly it is recommended that a Spot Improvement Design philosophy (Environmentally Optimised Design) be considered as the normal approach to basic access road provision whereby the simplest pavement structures are used for undemanding sections of road and the higher cost, improved structures be used on sections prone to failure, typically steep gradients. This same philosophy applied during alignment design may be used to limit construction costs by permitting the use of more extreme alignments and thus reducing earthworks and, sometimes, acquisition costs.

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➢Conclusions - General

- At this stage, the advantages and disadvantages for each pavement structure, other than the construction costs, cannot be clearly defined and it would be difficult to compile a table, or indeed a design methodology, that made a definitive recommendation for a particular pavement structure in particular circumstances. This emphasises that in order to draw conclusions in respect of specific pavement types, the medium and long term monitoring of the trial sections is of critical importance.

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➢Conclusions – Pavements

The following points are the general conclusions regarding the pavement trials highlighting the advantages and disadvantages of each:

- Standard NEC Gravel Pavement, Engineered Natural Surface and Sand Seal should not be used on problematic areas as these surfaces will not withstand heavy traffic, steep gradient or high erosive conditions i.e., rainfall.
- Sand Seals and Single Otta Seals are ideally suited to urban conditions with low traffic where dust from gravel roads is unacceptable. However, both of these surfaces will require periodic maintenance which could, ideally, be undertaken by the communities through which they pass.

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➢Conclusions – Pavements

- Concrete block paving, concrete pavements and bituminous bound pavements can be undertaken successfully by small scale contractors using imported and local materials. These initially expensive pavements result in sustainable pavements with reduced maintenance needs.

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➢Conclusions – Pavements

- Hand Packed or Mortared Stone Surfaces appear likely to offer the best value for money and are suitable for community based maintenance. However, unless very experienced artisans are used for the block preparation, extremely rough surfaces will result. Rough surfaces will in general be unacceptable to road users except in cases where the road was extremely bad and mostly impassable previously. Improvement of these areas to year round accessibility, using roughly hewn stone blocks, will be a huge improvement despite resulting in a rough surface. The standard of surface will improve as the community gains experience and will be better with mortared rather than hand packed stone.

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➢Conclusions – Pavements

- All of the pavements, but in particular the Engineered Natural Surface will perform much better during the wet season if the drainage is functional. A detailed drainage investigation should be conducted at the design stage resulting in drainage designed to function 'with nature' ensuring that water is not routed incorrectly. Routine drainage maintenance before the wet season will be of great help in ensuring that the road remains open throughout the wet season.
- Double Otta seals can be constructed using natural gravel which is well out of specification for normal surface dressed pavements, resulting in a durable surface which can be applied to all but the most severe areas. This construction is ideal for small contractors as it requires little plant and expertise, providing a bitumen distributor is available, but does require labour intensive care during construction.

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➢Conclusions – Pavements

- Geocells and Non-Reinforced Concrete pavements are suited to small contractors as suitable concrete can be mixed in small mixers using local materials. The specified thickness of the Geocell pavement can be less than that of concrete slabs however, the cost of the plastic Geocell form may negate some of this saving.
- Double Otta Seals, Concrete Blocks and Concrete pavements are suited to high traffic volumes. Also these pavements can be applied to steep gradients and sharp corners where traffic action on the surface is most severe.
- Hand Packed or Mortared Stone Surfaces, Paving Block surfaces are easily repaired reusing much of the materials by unskilled labour.

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➢Conclusions – Pavements

- Some of the chosen pavement methodologies were not as well suited to resources (human and/ or material) available in Houay Xai as others. An example was the knapped stone based pavements. Since there seems to be no history of knapped stone in the area (although the stone is available) it was very difficult to find experienced artisans to construct roads using this technique, which has proven successful elsewhere. Detailed investigations of the project area should highlight potential successful construction techniques.

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➢Conclusions – Contractor

- The contractor's staff had insufficient communication skills to benefit properly from the training given. Clear communication was found to be almost impossible (intentionally or unintentionally) due to the entire staff base being Chinese. It is recommended that future contracts clearly require local labourers, artisans and technicians to be employed. Not only does this have economic bearing on the local community, but also provides some feeling of ownership and ensures that the expertise created through training is not lost from the area. In the future these trained labourers will be able to construct other roads and to maintain existing roads.

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➢Conclusions – Contractor

- When using contractors to undertake small scale but accurate work in which they have little or no expertise, it is vital that considerable training is provided in order that the non-standard or unfamiliar construction techniques are conducted properly. It is recommended that small scale local contractors are trained and given a tender advantage over large international contractors. This will empower local communities, provide a sense of ownership within communities and ensure that expertise and economic benefit remains in communities.

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➢Conclusions – Contractor

- Problems were found when applying a research project to a commercial contractor, the contractor had little interest in the research and was primarily concerned with his costs and missed deadlines. An understanding must be shaped early in the project between client, funding agencies, consultant and the contractor such that research related contractual variations and requirements are defined, anticipated, allowable and enforceable. Care should be taken when compiling contract documents to ensure that they are adapted appropriately to the research aims; suitably weighted prequalification would be a significant advantage for research projects

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➢Conclusions – Maintenance

- The DPWT and Governor's office as well as the communities have a good understanding of the need for maintenance of the access roads in order to provide continued sustainable access. However, maintenance of the roads will depend largely on the willingness of the communities to contribute their labour and on the DPWT providing technical support and budget support when necessary.

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➢Conclusions – Maintenance

- A review of the maintenance organisation and funding shows that local participation is essential to the maintenance of access roads in Lao (PDR). Measures already exist to provide for such local participation, however, it is highly desirable that construction contracts should be structured to require the maximum possible local employment. Apart from the immediate benefits of employment, this will give the local community a sense of ownership of the road and help equip them with the necessary skills and understanding required for its future maintenance.

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➢Conclusions – Maintenance

- Maintenance considerations should be taken into account when selecting pavement types, for example gravel surfaces and bituminous seals require significantly more routine and periodic maintenance that concrete roads. Stone surfaces are potentially most suited for long term community maintenance without significant outside assistance or funding.

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➢ Conclusions – Dissemination

- Both soft and hard actions are required to make an impact of this work with practitioners. Soft action (Dissemination) will increase awareness and knowledge and will win hearts and minds leading to ownership by practitioners who will apply the concepts in their districts. Hard action (Mainstreaming) will result in the production of design guides, specifications and contract documents that allocate appropriate resources to the use of these techniques in the design and construction of rural access roads. This will again lead to the ownership by practitioners who will become confident in the success of these methods.

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➢Conclusions – Future

- Long term monitoring is necessary to making final conclusions as to the appropriateness and long term maintenance costs of the trial pavements.
- During the course of this project it has become apparent that it is important to embrace local materials and expertise. It is considered that substantially more effort should be concentrated during the design phase to ensure that poor and good sections of the road to be identified and the correct pavement solutions applied.
- Important aspects of the design that will ensure that a road is kept open throughout the year by carefully managing the water during the wet season are….

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➢Conclusions – Future

- ➢ Ensuring that the geometry is optimised to reduce both steep gradients and sharp curves even if this means increasing the length of the rural access road;
- ➢ Optimal pavement structures should be selected which use local materials and expertise as much as is practicable.
- ➢ Robust pavement structures should be applied to poor spots while more simple pavements are applied to the easy lengths;
- ➢ Depending on the materials and labour available it may be found beneficial to use more than one pavement design for different poor spots;
- ➢ The hydrology of the project area should be studied properly to allow a detailed drainage design to be conducted. The proper management of water will prevent weakening of the pavement structure due to ingress of water and erosion of the surface due to poor side and cross drainage;

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➢ Conclusions – Future

- ➢ Detailed assessments of slopes where they cannot be avoided will allow proper engineered solutions to be implemented reducing the chances of slope failures during the wet season.
- ➢ It is recommended that a suitable network of roads is identified and a spectrum of rural road design solutions incorporating Spot Improvement Design (Environmentally Optimised Design) using pavements varying from engineered natural material to gravel to durable paving be implemented and constructed. A rural road project would form an ideal testing ground in order to trial and formalise a detailed Spot Improvement Design.

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- Before

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- After

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- Establish Appropriate Solutions

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