SEACAP 17

Local Resource Solutions to Problematic Rural Road Access in Lao PDR

SEACAP Access Roads on Route 3

Objectives of Research

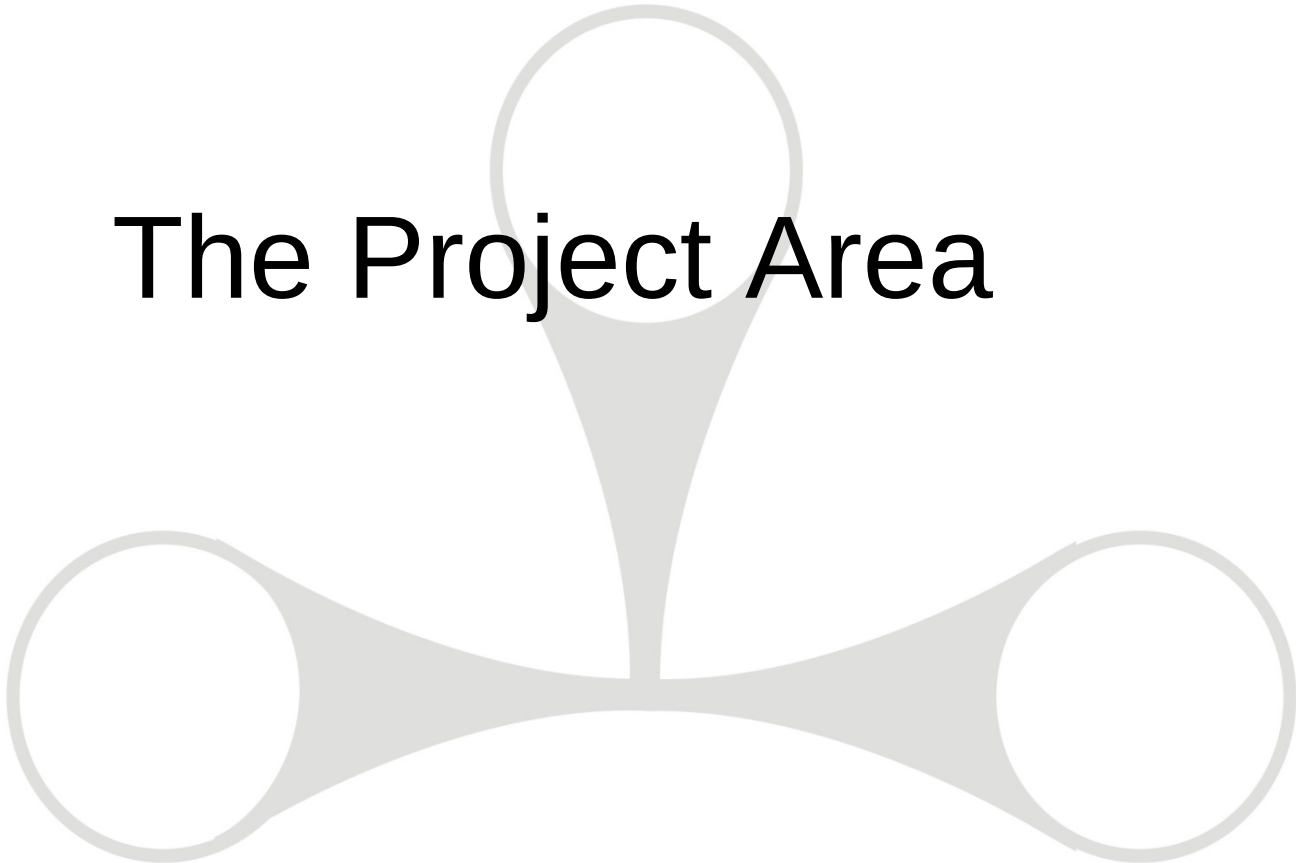
- Extend method of road construction
- Improve all year access to rural poor
- Low-cost local resource-based improvement
- Identify cost effective community based methods
- Introduce previous trial surfaces under SEACAP

Project Benefits

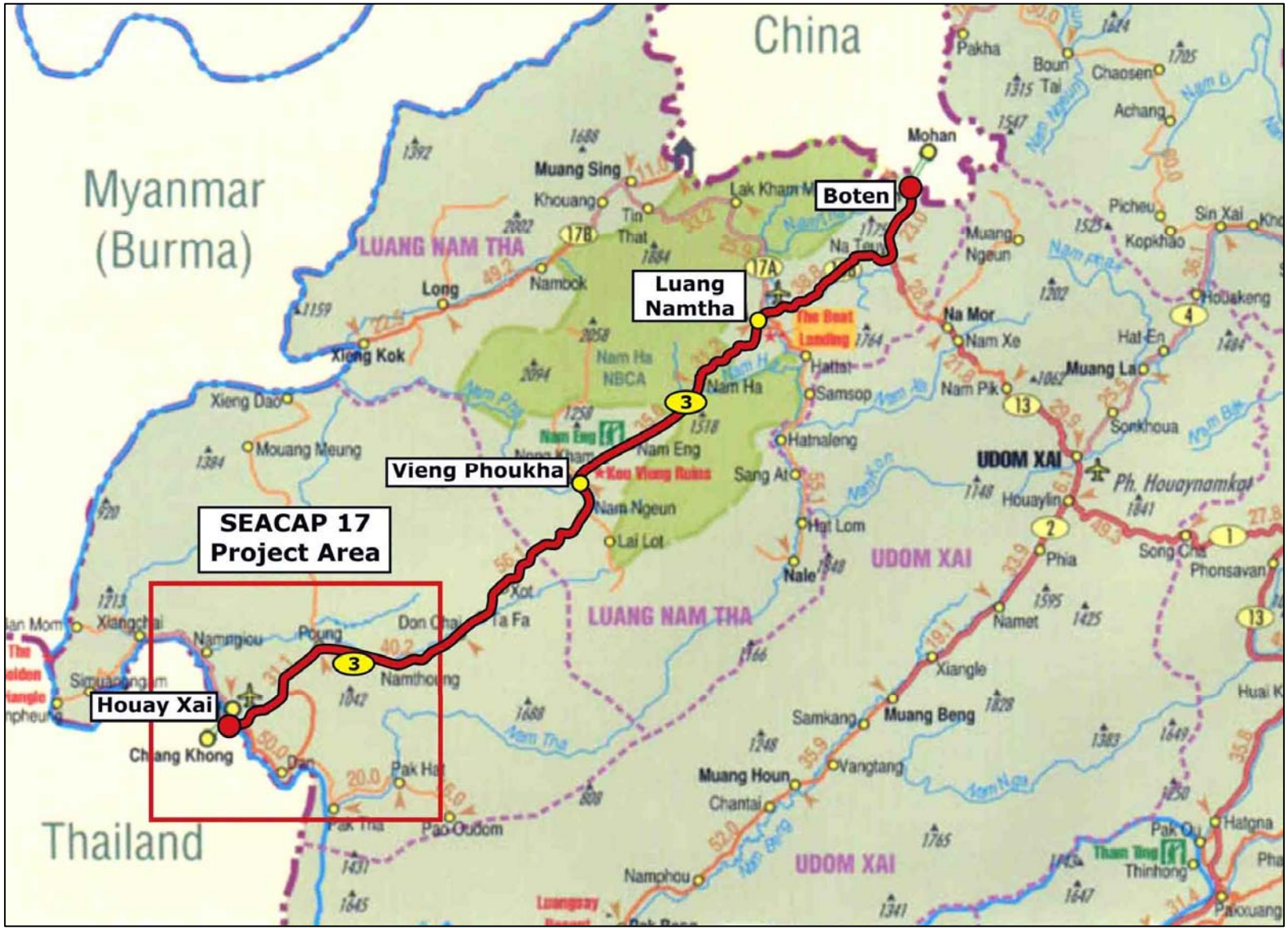
- Alternative local-resource based low-cost durable surfacing
- Lessons from other countries appropriately applied to the local context.

roughton international

The Project Area

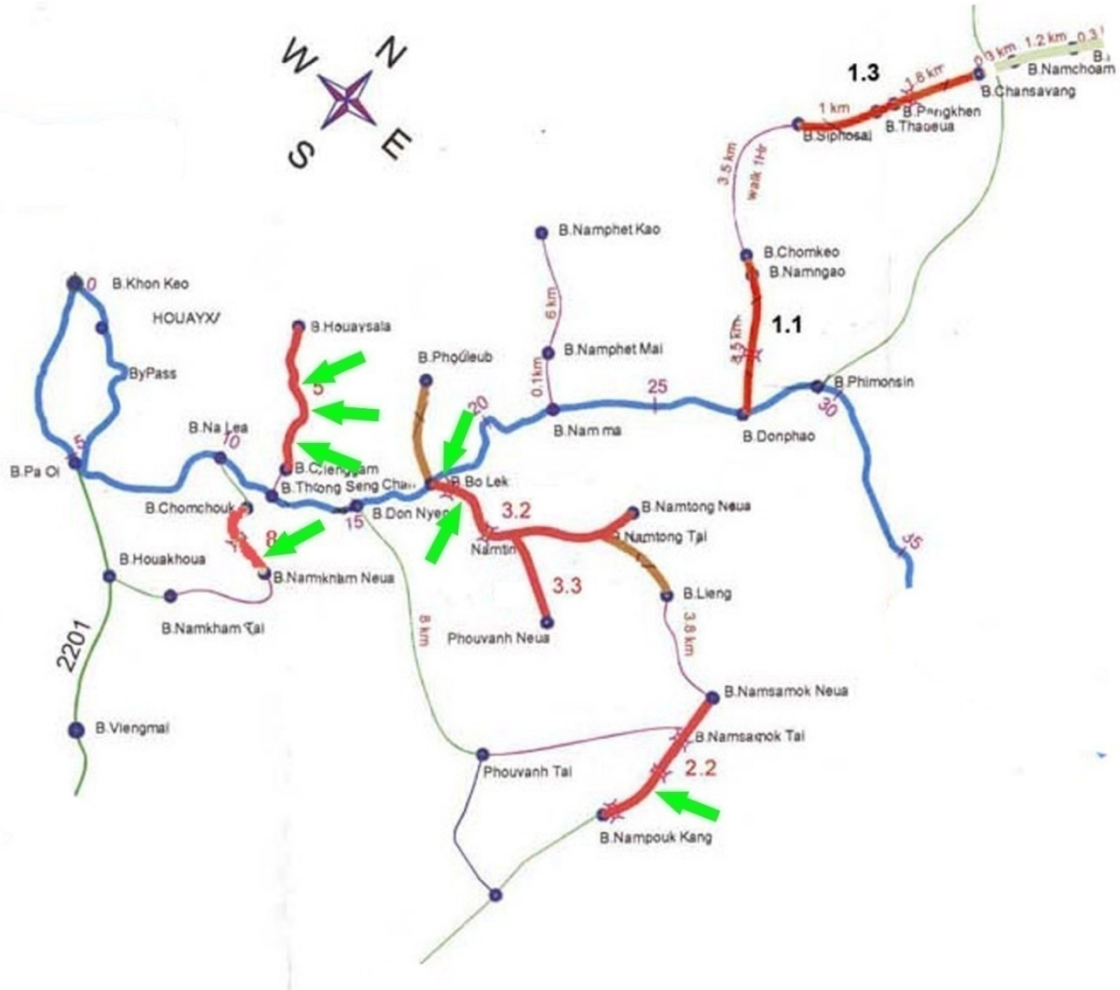


roughton international



roughton international

Location of Trial Sections

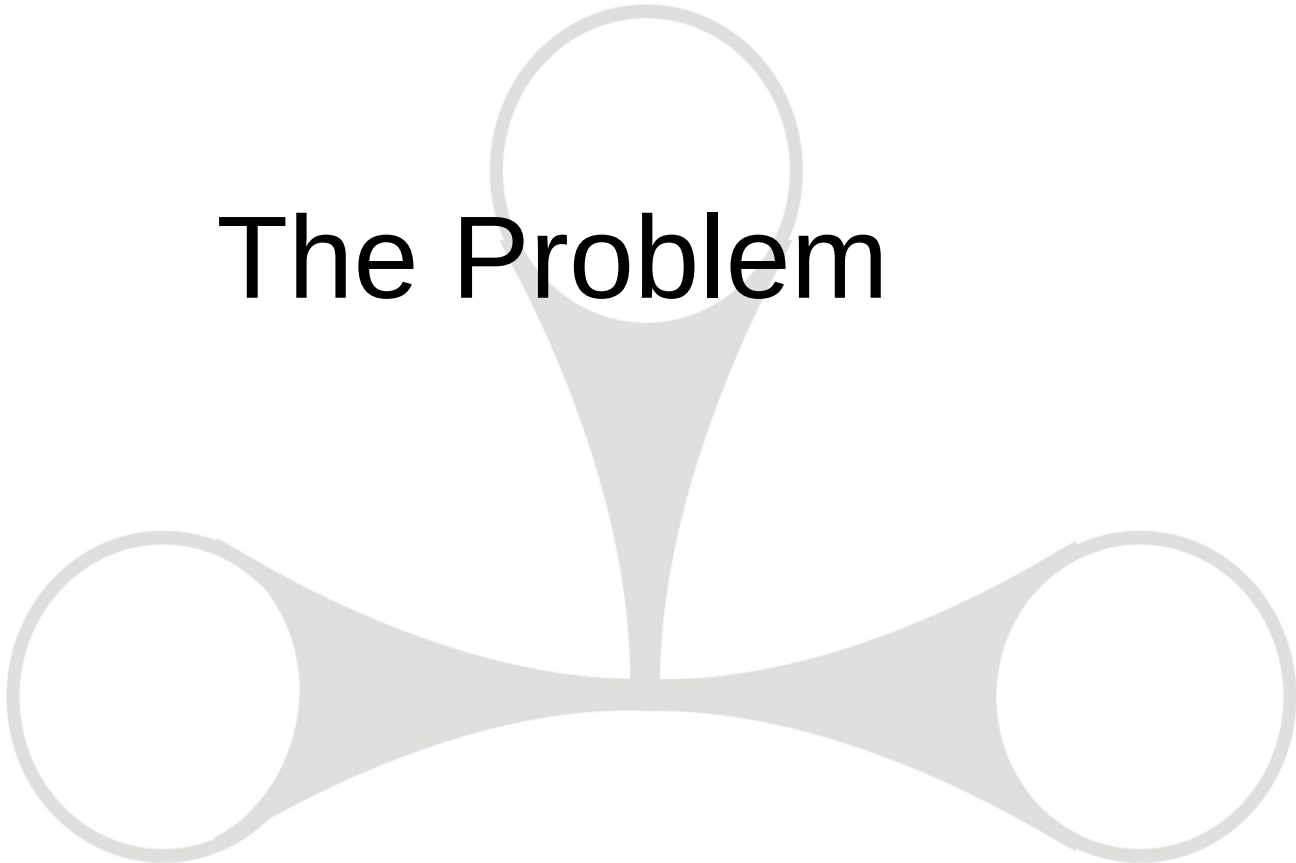


SEACAP – ADB Collaboration

Activities funded by SEACAP	Activities funded by ADB
Technical Assistance for managing and supervising the SEACAP access roads on specifically identified access roads of Route 3.	Cost of civil works associated with the selected access roads.

roughton international

The Problem



Existing Problem

- serious shortcomings with the use of gravel due to:
  - material quality & availability
  - Climate
  - Terrain
  - drainage provision
  - maintenance

Existing Problem (2)

- Rapid and serious pavement deterioration in:
  - flood prone areas
  - steep gradients
- Road blockages or collapse through landslips in hilly and mountainous terrain

roughton
international

roughton international

roughton international

roughton international

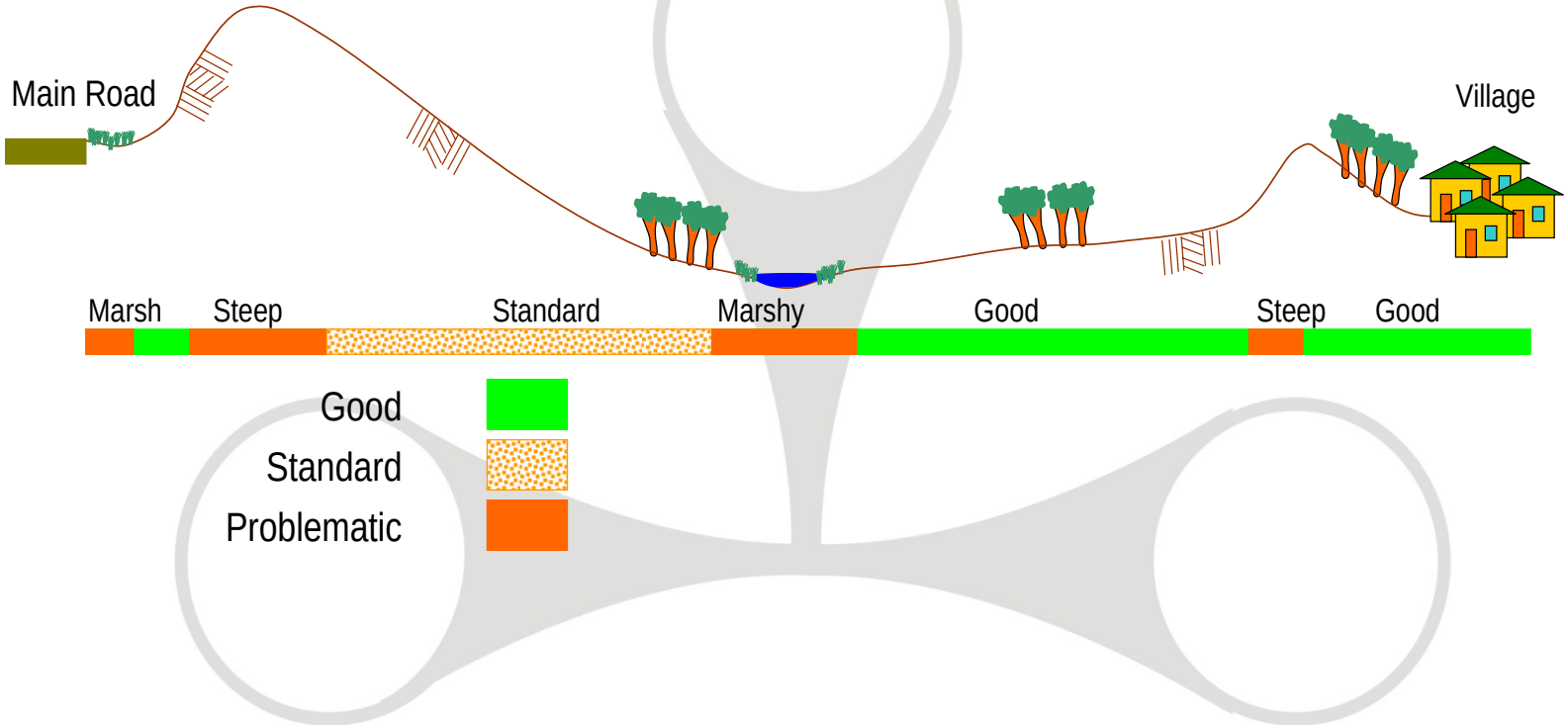
Environmentally Optimised Design and Spot Improvement Design

Accessibility Problems

- The main factors likely to render a gravel road impassable are:
  - Steep gradients
  - Soft wet areas
  - Severe erosion of the road and embankment due to water flowing across the road
  - Debris on the road due to material being washed from side slopes or landslides
  - Slope failures from poorly designed slopes above and below the road

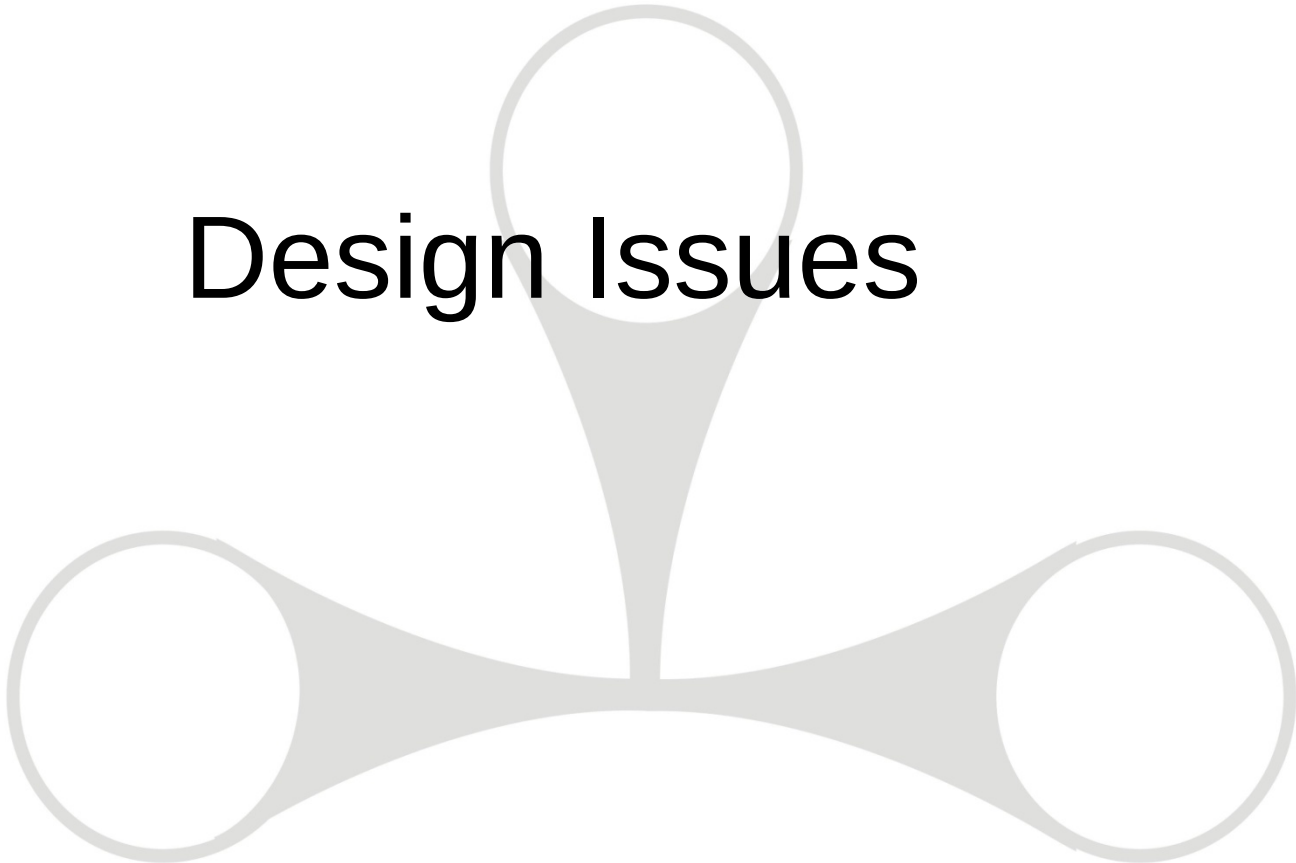
- EOD considers the variation of the different road environments along the length of the road:
  - steep gradients
  - wet and marshy areas
  - passage over easy terrain
- SID provides most suitable pavement type for the specific circumstances

Trial Section Definitions



roughton international

Design Issues



NEC Standard Design

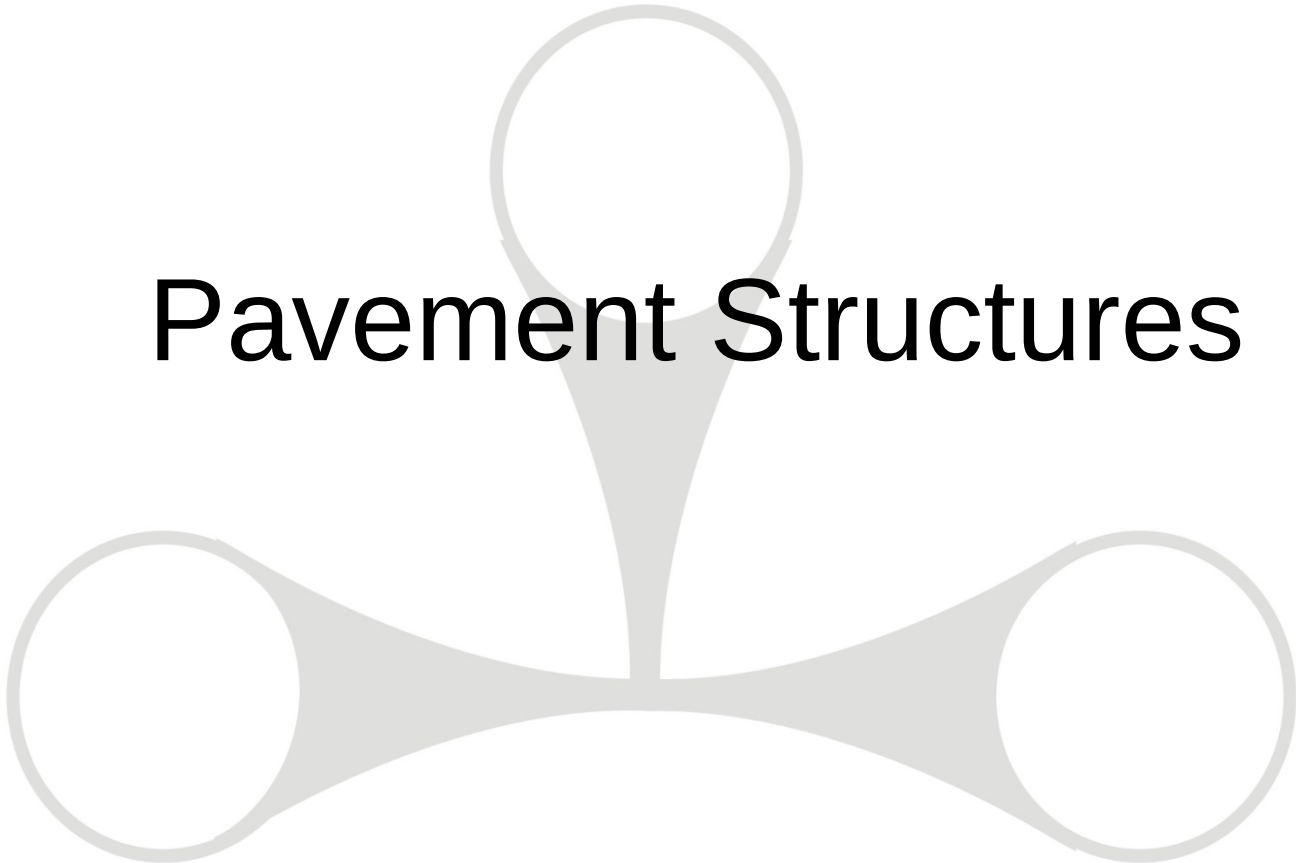
- 1990 Design Standards used:
  - Max gradient 12%
- New standards introduced in 2003
  - max. gradient increased to 15%
- New standards could minimise earthworks on steep sections
  - Use all weather surface
  - Improved drainage

Terrain

- Gradients >15% undesirable
- With proper design short steep sections can be more practical and economic
- Questions for SEACAP 17 trials:
  - Do the least expensive pavements perform adequately at low gradients?
  - At what gradient is it necessary to use a more expensive pavement to ensure year round access?
  - Do any particular pavement types offer performance advantages in specific gradient ranges?
  - Can the increased cost of reducing gradients be covered by the savings in pavement costs?

roughton international

Pavement Structures



Trial Pavement Options

- Bamboo Reinforced Concrete
- Otta Seal
- Sand Seal
- Geocell
- Hand Packed Stone
- Mortared Stone
- Concrete Paving Blocks
- Engineered Natural Surface

Bamboo Reinforced Concrete

roughton international

Otta Seal

Sand Seal

Geocell

Hand Packed Stone

roughton international

Mortared Stone

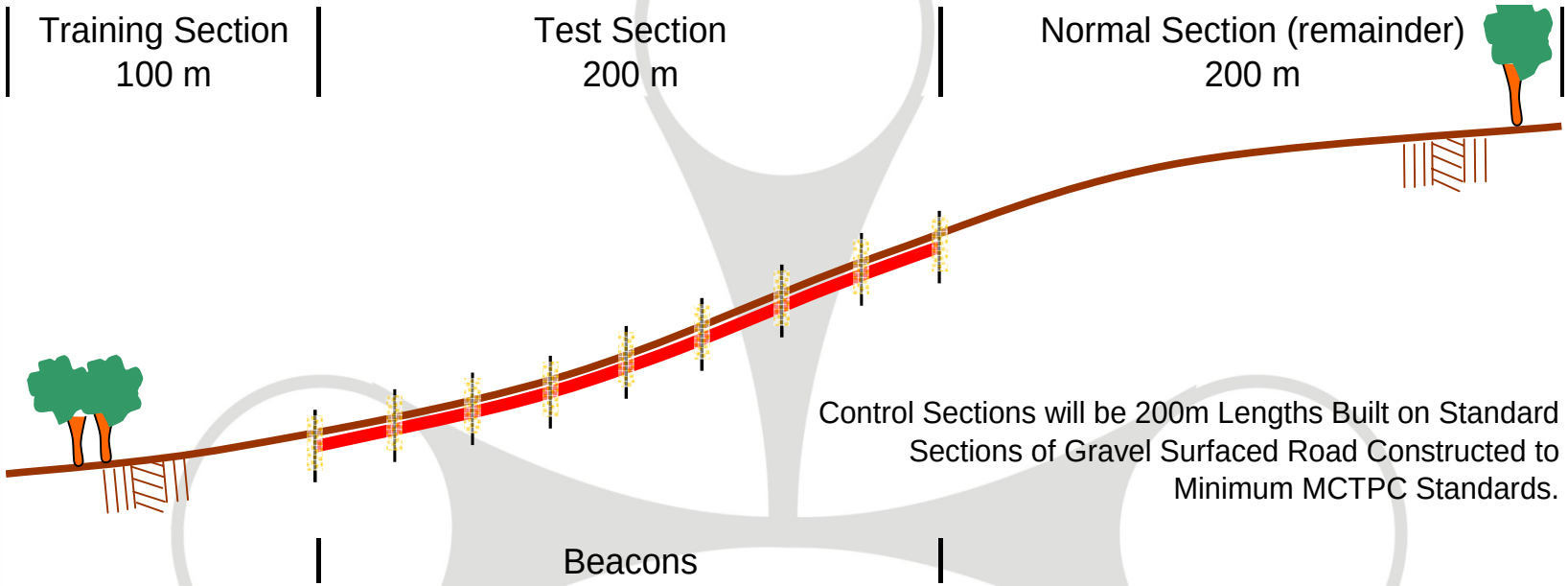
Paving Blocks

Pavement Construction

roughton international

Pavement Types		1	2	3	4	5	6	7	8	9
		Standard NEC Gravel	**Bamboo Reinforced Concrete**	**Geocell**	**Mortared Stone**	**Hand Packed Stone**	**Concrete Paving Blocks**	**Sand Seal**	**Otta Seal**	**Engineered Natural Surface**
Surface Layer	Type	Nat. Gravel CBR ≥ 25%	Concrete	Concrete	Stone	Stone	Blocks	Sand Seal	S.Seal + Otta Seal / Double Otta Seal	Nat.Gravel CBR ≥ 25%
	Thickness	200 mm	125 mm 150 mm	75 mm 100 mm 150 mm	65 mm	100 mm	65 mm	10 mm	20 mm 30 mm	
Sub-surface Cushion	Type		Sand	Sand	Sand	Sand	Sand			
	Thickness		20 mm	20 mm	50 mm	50 mm	20 mm			
Base	Type							C.Rock CBR≥80%	C.Rock CBR≥80%	
	Thickness							150 mm	150 mm	
Subbase	Type		Nat.Gravel CBR≥25%	Nat.Gravel CBR≥25%	Nat.Gravel CBR≥25%	Nat.Gravel CBR≥25%	Nat.Gravel CBR≥25%	Nat.Gravel CBR≥25%	Nat.Gravel CBR≥25%	Nat.Gravel CBR≥25%
	Thickness		125 mm	125 mm	125 mm	125 mm	125 mm	120 mm	120 mm	Levelling only
Selected Subgrade	Type	Nat.Gravel CBR≥8%	Nat.Gravel CBR≥7%					Nat.Gravel CBR≥7%		
	Thickness	300 mm	150 mm					150 mm		
Subgrade	Type	CBR≥5%	CBR≥5%	CBR≥5%	CBR≥5%	CBR≥5%	CBR≥5%	CBR≥5%	CBR≥5%	CBR≥5%
	Thickness	Varies	Varies	Varies	Varies	Varies	Varies	Varies	Varies	Natural ground

SEACAP Trial Sections



Control Sections will be 200m Lengths Built on Standard Sections of Gravel Surfaced Road Constructed to Minimum MCTPC Standards.

Results and analysis

Pavement Costs

	Pavement Description	Length (m)	Cost (USD)	Cost/m² (USD)
1	Hand Packed stone	500	11,073	6.328
2	Mortared Stone	600	13,288	6.328
3	Sand Seal	625	13,720	6.272
4	Single Otta Seal and Sand Cover	300	8,070	8.07
5	Double Otta Seal	200	6,370	9.1
6	Bamboo Reinforced Concrete			
	125mm	375	19,978	15.222
	150mm	200	12,417	17.739
7	Concrete Paving Block	500	51,793	29.596
8	Geocell Concrete Pavement			
	75mm	200	13,180	18.829
	100mm	100	8,212	23.464
	150mm	100	11,457	32.734
9	Engineered Natural Surface	400		
	Total	**4,100**	**169,560**	
	NEC Standard Gravel Control	1,400	11,891	2.427

Pavement Costs

- The costs of all the proposed trial pavements are substantially higher than for a simple gravel pavement
- The cost of 150 mm Geocell concrete pavement is almost double that of 150 mm Reinforced Bamboo concrete
- The cost of plain Concrete Block paving is remarkably high compared with the costs of Hand Packed or Mortared Stone pavement

Maintenance

- All pavements will require maintenance to preserve them
- There is in general, a trade-off between pavement first cost and subsequent maintenance costs.
- The most cost effective choice of pavement can be assessed on the basis of the estimated whole life cost of the pavement

Maintenance (2)

Pavement Type	Maintenance Activity
Gravel	Grade the surface to maintain an acceptable cross section shape;
	Patch potholes;
	Fill ruts and depressions;
	Regravel as required to maintain overall thickness.
Bamboo Reinforced Concrete	Seal cracks in concrete;
	Cut out and replace failed sections;
	Reseal construction joints if required.
Geocells	Replace damaged concrete blocks.
Mortared Stone	Repair damaged sections.
Hand Packed Stone	Replace damaged stones.
Concrete Paving Blocks	Replace damaged blocks.
Sand Seal	Seal cracks in bitumen;
	Patch potholes and reseal surface.
Otta Seal	Seal cracks in bitumen;
	Patch potholes and reseal surface.
Engineered Natural Surface	Patch potholes;
	Fill ruts and depressions;
	Regravel as required to maintain overall thickness.

Whole Life Costs

- The bulk of routine maintenance is common to all roads regardless of pavement type
- Assessed only the maintenance requirements of the various pavement types

WLC Assumptions

Gravel pavement: (Flat)	Grade twice yearly; Replace 25 mm of Gravel each year.
Gravel Pavement (Hilly):	Grade thrice yearly, Replace 35 mm of Gravel each year.
Engineered Natural Surface:	As for Gravel pavements
Bamboo RC:	Replace 2% and 2.5% of the pavement after each 5 years for 150 mm and 125 mm thicknesses respectively
Geocells:	Replace 2%, 3% and 4% of the pavement each 5 years for 150 mm, 100 mm and 75 mm thicknesses respectively
Mortared Stone:	Replace 4% of the pavement each 5 years
Hand Packed Stone:	Replace 6% of the pavement each 5 years
Concrete Paving Blocks:	Replace 3% of the pavement each 5 years
Sand Seal:	Replace 20% of the Seal every 2 years and 100% every 10 years
Single Otta Seal + Sand Seal:	Replace 50% every 5 years and 100% after 15 years
Double Otta Seal:	Replace 50% every 10 years

Economic Analysis

roughton international

Pavement Type	Cost US$/m2	Salvage Value	NPV	
			6%	10%
Mortared Stone	6.33	50%	5.58	5.68
Hand Packed Stone	6.33	30%	6.17	5.91
Engineered Natural Surface - level	0.23	50%	8.06	6.00
Standard NEC Gravel - level	2.43	50%	10.14	7.91
Double Otta Seal	9.10	60%	10.81	8.60
Engineered Natural Surface - hilly	0.23	50%	11.82	9.81
Concrete Paving Blocks	14.15	50%	12.20	10.60
Bamboo Reinforced Concrete 125mm	15.22	50%	12.98	12.38
Standard NEC Gravel - hilly	2.43	50%	13.90	12.53
Bamboo Reinforced Concrete 150mm	17.74	60%	14.46	13.16
Sand Seal	6.27	50%	15.75	13.39
Single Otta Seal with Sand Seal	7.69	60%	16.50	15.27
Geocells 75mm	18.83	40%	17.12	17.15
Geocells 100mm	23.46	50%	20.23	20.78
Geocells 150mm	32.37	60%	26.69	28.18

Economic Analysis (2)

- Results based on one Contractor's prices
- The Double Otta Seal is the best of the various bitumen based pavements
- Concrete block paving is a reasonably direct alternative to the hand-packed stone surfaces
- The NEC gravel pavement (Hilly) also comes out fairly well but does not guarantee all year access

Selection of Pavement Type

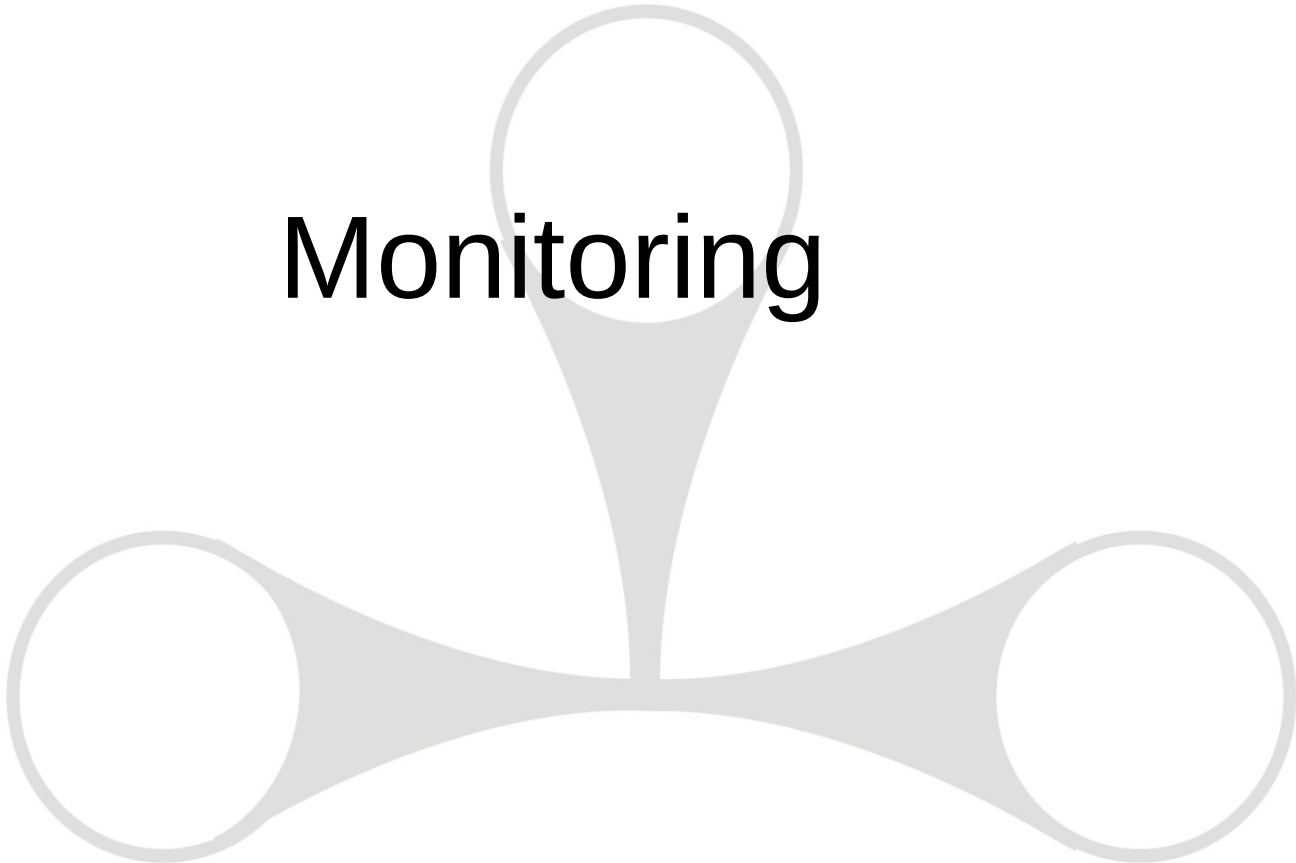
- Some pavement structures or surface types are more appropriate in certain circumstances
- EOD/SID design philosophy requires that substantial time in the field by experienced engineers
- More expensive, robust pavements will require less maintenance than the cheaper options

Selection of Pavement Type

Pavement Type	Key Markers									
	Local Materials	Flat Terrain	Steep Terrain	Populated Areas	Marshy Areas	Weak Subgrades	Small Contractor Suitability	Labour Based	Likely Cost Advantages	Maintenance Reduction
Standard NEC Gravel Pavement										
Bamboo Reinforced Concrete										
Geocell										
Mortared Stone										
Hand Packed Stone										
Concrete Paving Blocks										
Sand Seal										
Otta Seal										
Engineered Natural Surface										

roughton international

Monitoring



Monitoring (1)

- Visual Inspection and Surface Condition
- Visual condition surveys that assess the extent and degree of each of the particular modes of distress
- Graphic representations of the surface of the trial sections
- Use guidelines from SEACAP 27
- Photographic logging based on the beacons alongside the road

Monitoring (2)

- Surface Deformation Recording
  - rut measurements using a 3 m straight edge.
  - Surface roughness using a MERLIN apparatus.
  - Surface Texture
- Classified traffic counts
- Structural integrity using falling weight deflectometer

Conclusions
&
Recommendations

General

- Need for experienced engineers to spend time in the field during the design stage
- Data gathered on costs of constructing various types of pavement and the problems encountered in their construction.
- Problems encountered for research operation on the back of a commercial construction contract.
- Problems affecting long term data collection systems.
- Maintenance considerations should be taken into account when selecting pavement types

Pavement Options

- Standard NEC Gravel Pavement, Engineered Natural Surface and Sand Seal should not be used on problematic areas
- Concrete block paving, concrete pavements and bituminous bound pavements can be undertaken successfully by small scale contractors using imported and local materials
- Hand Packed or Mortared Stone Surfaces appear to offer the best value for money and are suitable for community based maintenance

Pavement Options (2)

- Otta seals can be constructed using natural gravel which is well out of specification for normal surface dressed pavements
- Geocells and Non-Reinforced Concrete pavements are suited to small contractors
- Double Otta Seals, Concrete Blocks and Concrete pavements are suited to high traffic volumes

Pavement Options (3)

- The construction cost of the all-weather surface types exceeds the cost of the standard gravel road significantly.
- All-weather surface types should be applied at the problematic spots on a rural access road where they are needed to maintain all weather access or for social reasons
- Spot Improvement philosophy should be applied as widely as possible given a shortage of funds to provide improved pavements throughout the road length

Contractual Issues

- Contractor's communication skills
- Applying research to commercial contract
  - Contractor only interested in time and cost
- Some specifications inappropriate to Lao PDR.

Recommendations

- Ensure that poor and good sections of the road are identified and the correct pavement solutions applied
- Small scale local contractors are trained and given a tender advantage over large international contractors.
- Future contracts clearly require local labourers, artisans and technicians to be employed - will be able to construct other roads and to maintain existing roads.

Recommendations (2)

- In order to keep a road open throughout the year:
  - The hydrology of the project area should be studied properly to allow a detailed drainage design to be conducted.
  - Detailed assessments of slopes to allow proper engineered solutions to be implemented reducing the chances of slope failures during the wet season
  - Optimal pavement structures should be selected which use local materials and expertise as much as is practicable

Recommendations (3)

- Spot Improvement philosophy to be considered as the normal approach to basic access road provision
  - simplest pavement structures are used for undemanding sections
  - higher cost, improved structures be used on sections prone to failure
- Limit construction costs by permitting the use of more extreme alignments


THANK YOU