A1

SEACAP 21

Slope stabilisation trials on Route 13N and Route 7 in Lao PDR

The Project in Detail

Xayphone Chonephetsarath, Tim Hunt, John Howell, Neil Carruthers

A2

SEACAP 21

The firms:

- Scott Wilson in association with Lao Consulting Group

The international staff:

- Tim Hunt (Team Leader) – Civil Engineer with an MSc in Soil Mechanics
- Dr Gareth Hearn – Engineering Geomorphologist with a degree in Geology and a PhD in Geomorphology
- Neil Carruthers – Engineering Geologist with a degree in Geology and an MSc in Engineering Geology
- John Howell – Bio-engineer with a degree in Geography and an MSc in Soil Science

The local staff headed by:

- Xayphone Chonephetsarath (Deputy Team Leader) with a degree in civil engineering

Combined experience of slope erosion and failures in 20 countries worldwide

A3

SEACAP 21

What is the project trying to achieve?

The objectives are:

- To use best-practice appropriate slope stabilisation methods utilising local materials and technologies
- To extend the present technologies to cover specific landslips
- To assist in the procurement and supervision of slope stabilisation trials
- To disseminate the results

A4

SEACAP 21

- Project area located roughly 250km north of Vientiane
- Mountainous terrain with project sites varying in elevation from 450m to 1450m above sea level
- Rainfall records very sparse but annual average probably in excess of 2000mm

A5

SEACAP 21

- Project commenced 9th October 2006
- 22 potential project sites initially identified, all showing active instability

A6

SEACAP 21

Four types of failure observed:

- Type A – shallow failure or slope erosion above the road
- Type B – shallow failure or slope erosion on loose fill slopes below the road

Types A and B treatable mainly using bio-engineering techniques

A7

SEACAP 21

- Type C – Deep seated failure on slopes above the road
- Type D – Deep seated failure on slopes above and/or below the road, passing through or beneath the road bench

Types C and D treatable mainly using geotechnical engineering techniques

A8

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Type A

A9

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Type B

A10

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Type C

A11

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- Type D

A12

Expected consequences if nothing done	Ranking				
	1	2	3	4	5
Occupied buildings damaged or destroyed	✓				
Road completely lost		✓			
Road partially lost			✓		
Road completely blocked			✓		
Slip debris likely to fall on pedestrians or vehicles, wall collapse			✓		
Wall damaged				✓	
Road partially blocked				✓	
Roadside drainage damaged or blocked					✓
Road subsidence					✓
Continued erosion destroying vegetation cover					✓

A13

Final Outcome				
Site No	Type	Risk Ranking	Phase	
			1	2
1	A & B	3	Yes	No
2	D	3	No	Extra
3	D	3	No	Yes
4	A & B	5	No	No
5	C/D?	3	No	Yes
6	A/C?	4	No	No
↓	↓	↓	↓	↓
21	D	3	No	No
22	D	3	No	No
Total			3	7+3

A14

SEACAP 21

SEACAP 21 PROGRAMME			
Task	06	2007	2008
Planning & Inception			
Phase 1			
Design & Documents			
Approvals & Bid			
Construction			
Phase 2			
Design & Documents			
Approvals & Bid			
Construction			
Manuals & Training			

A15

SEACAP 21

Our scope of work not only includes remediation of slope failures, but also examination of factors contributing to failure, such as:

- Original design
- Rainfall
- Geology
- Roadside drainage
- Road maintenance practice

Some of these factors will be discussed in more detail later.

We also wish to learn of slope problems elsewhere in Lao PDR and the methods that have been used to solve them

B1

BIO-ENGINEERING IN SEACAP 21

What is it?

- Bio-engineering means using vegetation to aid engineering structures
- Applicable only for slope protection and very shallow stabilisation: 0.5 metre or less; i.e. Type A and Type B sites
- More on this later in the Workshop

What is our starting point?

- Very limited previous use of bio-engineering in Lao PDR
- Widespread international experience available, particularly from other parts of south and south-east Asia
- Needs adaptation to the particular eco-climatic conditions in Laos
- Close relationship of vegetation with structural engineering works: bio-engineering is not done alone

B2

BIO-ENGINEERING
IN THE LAOS ROAD SECTOR

B3

BIO-ENGINEERING IN THE LAOS ROAD SECTOR

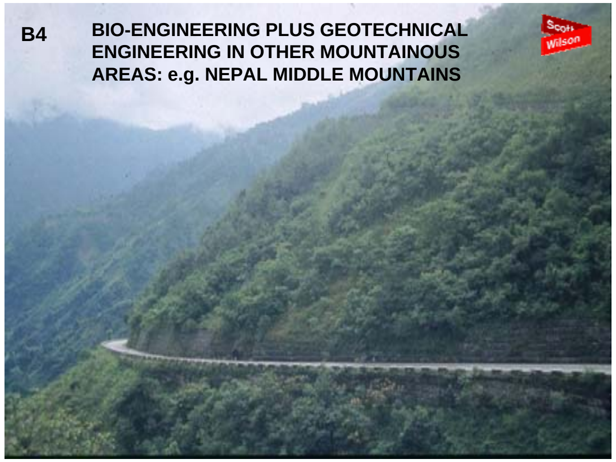
JICA experiment in Luang Prabang is informative and:

- Useful lessons can be learnt
- Like all trials, it shows where strengths and weaknesses occur
- Design details of drains and tow walls need to be examined
- The choice of species might benefit from broadening

BIO-ENGINEERING IN OTHER MOUNTAINOUS AREAS

Experience from other mountainous areas in Asia offers:

- Experience of the behaviour of different materials when saturated
- Understanding of slope protection in tropical-monsoon conditions
- Knowledge of the role of vegetation in engineering in this environment
- Low cost solutions appropriate to rural areas with limited resources, especially labour-based methods



B5

SEACAP 21 – PHASE 1 SITES: CRITICAL FACTORS

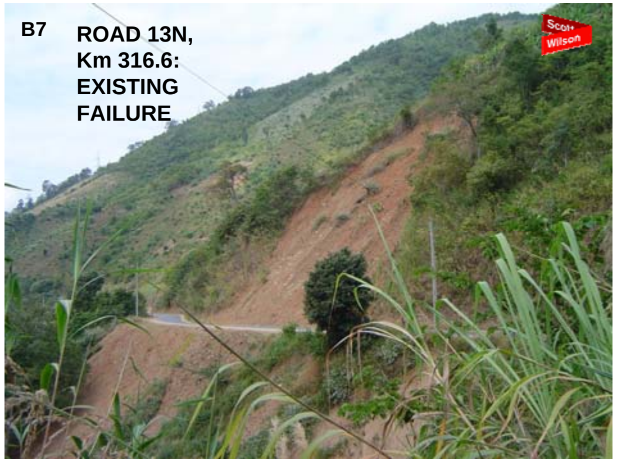
- Limited time for ground investigation
- Many detailed environmental variables will take some years to understand properly, especially for bio-engineering
- Opportunity to test out "rapid response": can Type A and Type B sites be evaluated and treated in a single dry season?
- Large, complex sites have been chosen deliberately
- Bio-engineering works usually take 2 seasons to get right on difficult sites (may be an issue in Phase 2)
- Technical approach can be demonstrated quickly; knowledge transfer and training will take longer

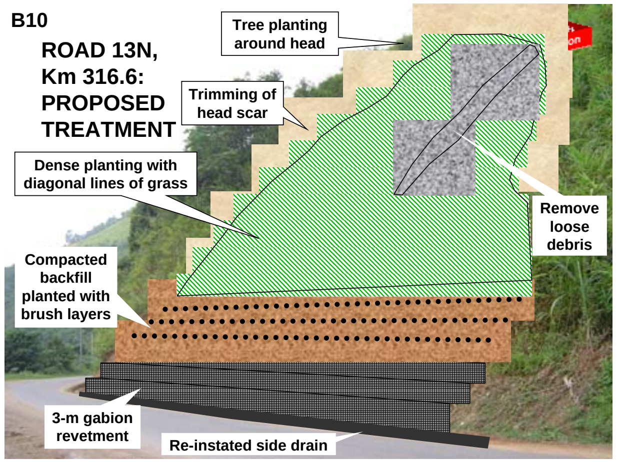
- These factors combine to make SEACAP 21 technically challenging
- There are many uncertainties because of this rapid research path
- But this adds to the potential knowledge that we should derive from this work

B6

SEACAP 21 – PHASE 1 SITES: MAIN ACTIVITIES

- Site evaluation and assessment
- Detailed topographic survey of sites
- Design of appropriate stabilisation and protection treatments
- Selection of appropriate low cost and bio-engineering techniques
- Identification of suitable and available plant species
- Drafting of technical specifications
- Detailed design drawings
- Estimation of costs and quantities
- Preparation of contract documents
- Preparation and training for site supervision





C1

SEACAP 21

Phase 2 Sites

Geotechnical Engineering

C2

SEACAP 21

Approach to Phase 2 Sites

Engineering Geological Mapping
↓
Ground Investigation
↓
Stability Analysis
↓
Detailed Design

C3

Slope angle & shape

Hydrology / water

Geology - soil & rock properties

Engineering Geological Model

Vegetation & land Use

Man made Features

Previous landslides

C4

Why Map?

C5

Why Map?

C6

Causes of Slope Failure

- Either rain water or surface water flows often trigger the landslides.
- Geology – weaknesses in soil and rock
- Man made causes – over-steepening of cut slopes and construction of fill slopes.

C7

C8

C9

Geology - Structural Weakness in Rock

C10

Geology - Structural Weakness in Rock

C11

Structural Weakness in Weathered Rock/soil

C12
Structural Weakness in Weathered Rock/soil

Relict (old) discontinuities in weathered rock/soil

C13
Ground Investigation on Phase 2 Sites

Ground investigation not always necessary or justified. At retaining wall sites we need to know:

- Depth to a suitable founding horizon such as In-situ ground/rock.
- Location of landslide slip planes.

May also need to know:

- Depth of fill material.

C14
Ground Investigation Methods

Trial Pits

- Allows visual assessment of ground
- Many pits can be completed in one day
- Can identify original ground level in fill slope
- Can identify landslide slip planes

Boreholes

- Greater depth
- Allows in-situ tests to determine soil strength
- 'Undisturbed' samples and rock core
- Requires specialist equipment and is more expensive

C15
Slope Stability Analysis

Factor of Safety = Forces Resisting Failure / Forces Driving Failure

Driving Forces

- Weight of soil/rock
- Weight of water/water pressure
- Surcharge loads

Resisting Forces

- Strength of soil and rock

C16
'Back' Analysis

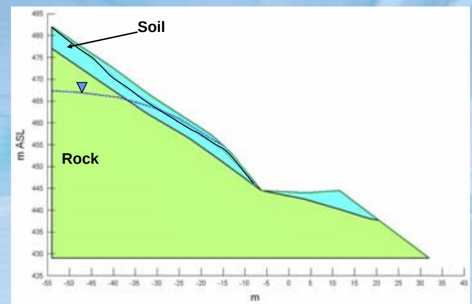
Immediately prior to failure we know the the Factor of Safety was = 1 (UNITY)

From the mapping we can determine:

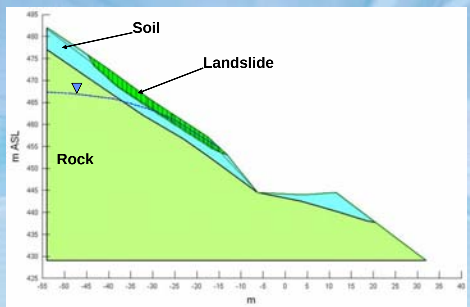
- Original ground level.
- Position of failure plane.
- Type of failure i.e. planar, rotational etc

Back analysis then allows us to "estimate" the groundwater level and soil strength at the time of failure.

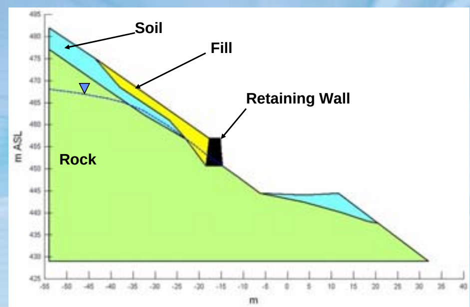
C17
Back Analysis Example



C18
Back Analysis Example



C19
Back Analysis Example



C20
Detailed Design

Geotechnical solutions include:

- Slope face protection – bio-engineering, masonry revetments
- Regrading / earthmoving (fill slopes)
- Drainage works
- Retaining structures

C21

Retaining Structures

- Likely to be used above and below the road.
- Most commonly constructed of Mortared-Masonry in Laos and SE Asia (gravity walls).
- Gabions and ‘composite’ walls can also be used

C22

Typical Mortared-Masonry Wall

C23

Typical Composite Wall