The Project in Detail

Xayphone Chonephetsarath, Tim Hunt, John Howell, Neil Carruthers

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

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

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

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

Four types of failure observed:
- Type A – shallow failure or slope erosion above the road
- Type B – shallow failure or slope erosion below the road, passing through or beneath the road bench
- 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 A and B treatable mainly using biotechnical engineering techniques

Types C and D treatable mainly using geotechnical engineering techniques
Continued erosion destroying vegetation cover

Road subsidence

Roadside drainage damaged or blocked

Road partially blocked

Wall damaged

Road partially blocked

Roadside drainage damaged or blocked

Road subsidence

Continued erosion destroying vegetation cover

Expected consequences if nothing done

<table>
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<tr>
<th>Ranking</th>
<th>Occupied buildings damaged or destroyed</th>
<th>Road completely lost</th>
<th>Road partially lost</th>
<th>Road completely blocked</th>
<th>Slip debris likely to fall on pedestrians or vehicles, wall collapse</th>
<th>Wall damaged</th>
<th>Road partially blocked</th>
<th>Roadside drainage damaged or blocked</th>
<th>Road subsidence</th>
<th>Continued erosion destroying vegetation cover</th>
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Final Outcome

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<th>Risk Ranking</th>
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SEACAP 21 PROGRAMME

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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.

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.

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.
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

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

ROAD 13N, Km 316.6: EXISTING FAILURE

- Shifting cultivation on slope above failure may have affected slope hydrology
- Road benched into steep lower section of a long convex slope
- Spring water emerging on slope to SE of failure
- Slope below road destabilised by large volume of debris tipped in emergencies
- Steep planar debris slide averaging 50°
- Slope composed of fragmented phyllite and residual soil, transported and mixed to make a weak colluvial mass

ROAD 13N, Km 316.6: LANDSCAPE APPRAISAL

- Slope composed of fragmented phyllite and residual soil, transported and mixed to make a weak colluvial mass
- Road benched into steep lower section of a long convex slope
- Spring water emerging on slope to SE of failure
- Steep planar debris slide averaging 50°
- Over-steep slope toe (52°)
- Numerous rills (small gullies are active)
- Few exposures of in situ rock
- Few areas still moving as a mass
- Loose remaining debris masses

ROAD 13N, Km 316.6: DETAILED SITE ASSESSMENT

- Over-steep slope toe (52°)
- Few exposures of in situ rock
- Steep (44°) translational debris slide: shattered phyllite in a matrix of fine residual soil (high clay and silt fractions)
- Crumbling head scar at 55-60°

Phase 2 Sites

Geotechnical Engineering

Approach to Phase 2 Sites

Engineering Geological Mapping
- Ground Investigation
- Stability Analysis
- Detailed Design
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.
Structural Weakness in Weathered Rock/soil

Relict (old) discontinuities in weathered rock/soil

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.

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

Trial Pits
- Many pits can be completed in one day
- Can identify original ground level in fill slope
- Can identify landslide slip planes

Back Analysis Example

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

Back Analysis Example

'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.

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