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PEACE INDEPENDENCE DEMOCRACY UNITY PROSPERITY

MPWT - SEACAP 21 - DFID

DF 68: SEACAP PRACTITIONER MEETING (SPM)
STUDY TOUR TO THE SEACAP 21 TRIALS
5-7 NOVEMBER 2008

STUDY TOUR REPORT

SUBMITTED BY

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in association with

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SD & XP Consultants Group

November 2008

SEACAP 21 Slope Stabilisation Trials

STUDY TOUR REPORT

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SEACAP 21 STUDY TOUR

1. THE STUDY TOUR

1.1 The objectives of the Study Tour

The objectives of the study tour were to give the participants of the 2008 SEACAP Practitioners Meeting the opportunity to see some of the landslide stabilisation works carried out under SEACAP 21/001 and to gain an understanding of the issues involved. In addition it was to be an enjoyable experience and involved some interaction with and by the participants rather than mere observation.

1.2 The programme

The actual programme comprised:

5th November. 3.30 pm. Departure for Vang Vieng in two buses, arriving 7.30pm
6th November. 8.00 am. Departure in two buses for SEACAP 21/001 sites
6th November. 5.30 pm. Bus 1 Return to Vang Vieng hotels
6th November. 7.15 pm. Bus 2 Return to Vang Vieng hotels
7th November. 7.45 am. Bus 1 Departure for Vientiane Airport and Vientiane Restaurant
7th November. 8.30 am. Bus 2 Departure for Vientiane Restaurant.

1.3 The participants

A total of 73 SPM participants attended the Study Tour from a number of countries including Sri Lanka, Vietnam, Cambodia, Laos, Indonesia, Nepal, Philippines, Ethiopia, Ireland and the UK. Many of these represented roads ministeries, aid agencies, and individual projects.

1.4 The sites visited

The following landslide sites were visited, the duration of each visit usually varying from 10 to 45 minutes:

Road 13N Km 238.0

This was a Phase 1 bio-engineering site which was now displaying some distress following the above-average rainfall in the 2008 wet season. This was used to discuss the merits and shortcomings of bio-engineering, as well as the shortcomings of the Performance Based Maintenance Contracts in the disposal of landslide debris.

Road 13N Km 239.3

A significant new landslide occurred here during the 2008 wet season which provided the ideal opportunity for discussing with the participants why the landslide had occurred, what sort of stabilising measures might be required, and what ground investigation would be advisable. This site was visited last, to give everyone the benefit of seeing what had been done at the other landslide sites before making their own judgements here.

Road 13N Km 242.6

This was a site where erosion protection was considered more appropriate, and the use of a hand-applied reinforced concrete surfacing as a substitute for shotcrete provoked much discussion.

Road 13N Km 254.0

This site was useful to emphasise the importance of maintaining culvert outlets and drainage courses in mountainous terrain, which are otherwise often ignored or forgotten.

Road 13N Km 260.3

The instability at km 260.3 represents the largest landslide site within the entire project area. This provided the opportunity to discuss the merits of carrying out engineering geology mapping and slope movement monitoring in order to understand better the mode of failure. In addition it led on to the discussion of doing nothing and accepting a higher annual maintenance commitment rather than spending a potentially considerable sum of money on road realignment. The very recent bio-engineering behind and above the new retaining wall provided on-site examples of the adjacent bio-engineering demonstrations of grass slip planting, truncheon cuttings and brush layering.

Road 7 Km 3.3

Km 3.3 was the most costly SEACAP 21/001 site to stabilise due to the need for a large retaining wall. Instability had largely arisen due to the neglect of erosion below a cross culvert outlet structure, again emphasising the importance of timely intervention.

A handout fully explaining the works undertaken at each site was given to each participant on boarding the buses, a copy of which is shown in Appendix A.

1.5 The conduct of the site visit

In general, the site visit went extremely well with the one exception of hold-up of Bus 2 for an hour on the outbound journey between Vang Vieng and Kasi. It would appear that the Performance Based Maintenance Contract contractor was in the process of reconstructing Road 13N at a steeply inclined and curved section, with the result that following heavy rain on the previous day the road was very muddy and slippery. Bus 1 managed to navigate this with a little difficulty, but the driver of Bus 2 decided that it was too dangerous. Eventually, however, the problem was solved, but the resulting delay meant that Bus 2 returned to Vang Vieng more than 1.5 hours later than planned.

The routing of the buses was originally organised so that only one bus would visit a particular site at one time, to avoid the potential problem of parking and handling large numbers of pedestrians except at the lunch site. With the 1 hour delay to Bus 2, however, this was never a problem.

Tim Hunt, Team Leader for SEACAP 21/001, provided the technical commentary for Bus 1 and Gareth Hearn, Geotechnical Engineer 1, the technical commentary for Bus 2. At each site there was a good exchange of views between the technical commentators and the participants.

Each bus was accompanied by one pickup, and warning signs were erected prior to participants disembarking at each site, and dismantled on departure. Bus stopping points were well marked. This exercise went well.

The bio-engineering demonstration was well received and the Deputy Team Leader of SEACAP 21/001, Xayphone Chonephetsarath, gave an excellent commentary on the various techniques being displayed.

Boxed lunches and water were provided at Km 260.3, tents, tables and chairs having been earlier set up. The late arrival of Bus 2 meant that the participants on Bus 1 may have had more than their fair share of food, but this was only a minor irritant.

1.6 Feedback

Feedback from the participants was excellent and it would appear that they all enjoyed the visit and felt that they had had a good learning experience as well.

1.7 Lessons learned

Although the weather during the site visit was generally good, the unseasonal rain during the previous few days gave considerable cause for concern. The entire visit might have had to be abandoned had the heavy rain continued.

One of the participants represented a disability charity and was required to use a wheelchair to gain access to the individual sites. Although he had a helper, this sometimes created a delay to the bus transport.

However, there is no doubt that the detailed preparation and planning carried out by others (Crown Agents, David Salter, Exotissimo Travel), together with the detailed Terms of Reference under which the technical consultants were obliged to operate, paid off well.

2. APPENDIX A

Handout given to participants at the beginning of the site visit

SEACAP PRACTITIONERS MEETING

SEACAP 21 STUDY TOUR

NOVEMBER 5 – 7

SEACAP 21 STUDY TOUR

Road: 13N **Location:** Km 238.0

Description of failure:

Above Road: Extensive active shallow slope failure 25m wide and roughly 40m high with crest of failure approaching base of high tension electricity pylon (now since relocated), overlying 10m high phyllite outcrop Weathering Grade (WG) II-III.

Below Road: Actively failing 30 deg loose slip debris slope 40m down to watercourse, but gradually re-vegetating naturally.

Cause of failure:

Above Road: Not known, but possibly associated with land use/natural drainage beyond crest of failure.

Below Road: Surface runoff from road onto unstable loose slip debris slope creating further instability.

Investigation works carried out:

Topographic mapping and engineering geological mapping

Road: 13N **Location:** Km 238.0

Description of stabilisation measures:

Above Road: Back scar trimmed and loose slope debris removed. Exposed surface re-profiled and compacted. Stone-lined slope drains constructed. Gabion check dam constructed on slope. Shrub seeding in rock areas as required. Diagonal grass lines planted. (Work carried out in June 2007)

Below Road: Fill slope debris trimmed to a rounded profile. Remaining debris smoothed and compacted. Live check dams installed in gullies on fill slope. Grass strips planted on slopes less than 35 deg and brush layers on slopes greater than 35 deg.

Performance of stabilising measures:

Above Road: Satisfactory up to July 2008 when extended periods of heavy rainfall caused the upper portion of the above-road slope to slump and some masonry lined slope drainage channels to be destroyed.

Below Road: Satisfactory up to July 2008 when material which had slipped onto the road from the above-road slope was cleared and dumped on top of the below-road fill slope, destroying the bio-engineering measures and creating further instability.

Road: 13N **Location:** Km 242.6

Description of failure:

Below Road: Large 80m width by 70m length erosion scar active below road. Original road lost and new road on alignment shifted by half road width, but failure has progressed to masonry edge wall. Exposed surface comprises slate/phyllite that varies from competent rock of Weathering Grade (WG) II-III to more highly weathered material. Quartz veins are present on the north eastern side of the backscar. Further slate outcrops are present lower in the base of the landslide scar. Two major joint sets were identified.

Cause of failure:

Below Road: Cause of original failure not known but erosion is continuing due to presence of surface runoff down steep crest profile in un-vegetated WG IV-V material.

Investigation works carried out:

Topographic mapping and engineering geological mapping

SEACAP 21 STUDY TOUR

Road: 13N **Location:** Km 242.6

Description of stabilising measures:

Below Road: Upper 5m edge of backscar re-reprofiled. Original intention was to protect backscar with reinforced shotcrete, but due to the absence of specialist equipment/contractor, this was substituted with cast in-situ hand-applied 75mm thick continuously reinforced concrete.

Performance of stabilising measures:

Below Road: Good

Road: 13N **Location:** Km 254.0

Description of failure:

Below Road: Culvert head/retaining wall undercut due to outlet scour. Left Hand Side (LHS) of gully also scoured in highly disturbed rock mass with adverse jointing. Masonry edge wall 1.5m deep also failed due to scour of foundation at up-chainage end. Total affected area 30m wide by 50m downslope. Large deep slide on down-chainage end undergoing active movement.

Cause of failure:

Below Road: Failure apparently occurred during the 2004 wet season, the deep gully erosion from the culvert outlet triggering the up-chainage slide. It would appear likely that the original gully erosion had been occurring unnoticed for some time prior to the 2004 wet season.

Investigation works carried out:

Topographic mapping and engineering geological mapping. One borehole taken down to 15m below road level immediately behind failed retaining wall, with Standard Penetration Tests at 1.5m intervals. This indicated 5m fill overlying WG IV-V phyllite.

Road: 13N **Location:** Km 254.0

Mortared masonry channel

Mortared masonry retaining wall

Description of stabilising measures:

Below Road: 35m x 6m high mortared masonry retaining wall constructed, although original design length of 50m was reduced to save money. 3m wide mortared masonry drainage channel constructed in existing gully. Grass slips planted and brush layers installed. Live check dams planted in gullies.

Performance of stabilising measures:

Below Road: Satisfactory although ongoing gradual movement of slope on down-chainage side close to culvert outlet structure will need regular inspection with the possibility of further stabilisation works in the future.

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Road: 13N **Location:** Km 260.3

Description of failure:

Above Road: Major failure affecting the entire road bench over a 150m length of road. Tension cracks associated with the main failure extend more than 100m upslope. 2m high toe wall installed in 2004 by the Department of Public Works and Transport already exhibiting significant movement and cracking. Side drain and cross culvert inlet totally blocked. Exposures in failed cut slopes from Ch 260+360 comprise some highly fractured argillaceous rock (WG III). More weathered siltstone/mudstone (WG IV-V) with some Phyllitic texture (Metasiltstone exposed higher in backscar of main failure).

Below Road: Area used for spoil dumping. Significant gully erosion taking place at original cross culvert outlet location, although inlet completely blocked with slope debris. One limestone exposure is visible. Hillside continues down to a valley base/stream course where further limestone outcrops are present.

Cause of failure:
Above Road: Possible reactivation of larger, relict failure. Relevance of geologic boundary between argillaceous rock and limestone is uncertain.

Below Road: Gully erosion in loose fill from road and cut slope run-off due to adverse road cross fall.

Investigation works carried out:

Topographic mapping and engineering geological mapping. Three machine dug trial pits taken down to 5m depth in an attempt to locate slip plane, but results inconclusive. Borehole located near cross culvert taken to 17.5m depth with Standard Penetration Tests at 1.5m intervals indicated 6m made ground overlying WG IV-V argillaceous rock. 20mm dia pvc standpipe installed to 12m depth to act as a slip indicator. Slope movement monitoring carried out monthly in the 2007 wet season and at the end of the 2008 wet season. Neither the slip indicator nor the movement monitoring gave any meaningful results.

Road: 13N **Location:** Km 260.3

Description of stabilising measures:

Given the large extent of the existing instability which is also known to extend beneath the road, the stabilising measures have been designed only to address the current situation on a temporary basis, since a permanent solution will be very expensive and could involve a complete relocation of the road.

Above Road: Mortared masonry roadside drain reconstructed throughout length of failure area. Later decision to extend the existing mortared masonry retaining wall with a new 35m long by 3m high composite masonry retaining wall. Grass slip planting and brush layering on slope above the retaining wall

Below Road: Existing cross culvert cleared and new gabion outlet structure constructed.

Performance of stabilising measures:

Above Road: Given the wider extent of ground movements taking place, the slope improvement measures constructed are performing satisfactorily.

Below Road: Satisfactory but additional gabion check dams necessary to prevent further gullying below existing culvert outlet.

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Road: 7 **Location:** Km 3.3

Description of failure:

Below Road: Major failure affecting part of LHS road surface and fill slope/natural ground below masonry edge wall on 1.5m high gabion (culvert location?). Additional deep scouring down-chainage adjacent to road exposing black clay (shale). Road located on embankment on vertical sag curve (saddle). On RHS, evidence of movement of cracked masonry upstand at crest of 6m fill slope. Total affected area roughly 60m wide by 30m downslope.

Cause of failure:

Below Road: A cross road culvert is located in the low point/saddle of the road. The culvert drains artificial ponds to the north of the road to an incised gully on the south. The ponds are artificial and have modified the hydrology of the area. Incision and erosion by surface water has removed support from the toe of the slope and this has probably triggered failure. The stream flow rate has been artificially increased by pond and culvert construction. In addition, high runoff towards base of sag curve and lack of roadside drainage may have also created erosion conditions in weak fill.

Investigation works carried out:

Topographic mapping and engineering geological mapping. 2 machine-dug trial pits excavated to 5m depth. Borehole located in road immediately behind failed retaining wall, taken to 7.5m depth, with Standard Penetration Tests at 1.5m intervals. This indicated fill overlying WG IV-V argillaceous rock.

Road: 7 **Location:** Km 3.3

Description of stabilising measures:

Below Road: 75m long mortared masonry retaining wall constructed on LHS, 6m high. New masonry roadside drain with outlet to RHS. Existing culvert cleared and new gabion headwall and outlet structure constructed on LHS. Gabion check dam constructed in existing drainage course to reduce erosion and scour. Grass slips planted on re-graded ground below new retaining wall and above culvert inlet and outlet structures.

Performance of stabilising measures:

Below Road: Good, but new roadside channel necessary on LHS up-chainage of retaining wall to ensure road runoff is directed into roadside outlet away from wall structure.

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Road: 13N **Location:** Km 239.3

Description of failure:

Below Road:

Cause of failure:

Below Road:

Investigation works carried out:

<table>
<tr><td colspan="8">LANDSLIDE REPORT</td></tr>
<tr><td colspan="8">Location (road and km):</td></tr>
<tr><td colspan="3">Date of report:</td><td colspan="5">Reporter's name:</td></tr>
<tr><td colspan="2">Situation</td><td colspan="2">Material</td><td colspan="2">Blockage</td><td colspan="2">Failure</td></tr>
<tr><td>Above road</td><td></td><td>Rock</td><td></td><td>Whole road</td><td></td><td>Whole road</td><td></td></tr>
<tr><td>Below road</td><td></td><td>Debris</td><td></td><td>Part of road</td><td></td><td>Part of road</td><td></td></tr>
<tr><td>Through road</td><td></td><td>Soil</td><td></td><td>Side drain only</td><td></td><td>Side drain only</td><td></td></tr>
<tr><td colspan="4">Geometry of slipped area</td><td colspan="4">Topography</td></tr>
<tr><td colspan="3">Length (perpendicular to road) m</td><td></td><td colspan="3">Original slope angle</td><td></td></tr>
<tr><td colspan="3">Width (parallel to road) m</td><td></td><td colspan="3">Failure angle</td><td></td></tr>
<tr><td colspan="3">Depth (estimated) m</td><td></td><td colspan="3"></td><td></td></tr>
<tr><td colspan="3">Estimated volume (L x W x D) m^3</td><td></td><td colspan="3">Associated retaining wall</td><td></td></tr>
<tr><td colspan="8">Sketch of failure/additional notes:</td></tr>
<tr><td colspan="8">Probable cause of failure:</td></tr>
<tr><td colspan="8">Consequences if nothing done:</td></tr>
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Practical Demonstration of Bio-engineering Applications

What is bio-engineering? Bio-engineering is the use of plants to undertake light engineering tasks. Certain types of plants can be used to control erosion and shallow landslides. Often it is used in association with small-scale structures.

When should bio-engineering techniques be used?

Bio-engineering techniques should normally be used to stabilise or prevent shallow slope movements where the depth to the sliding surface is up to 0.5 m, and to protect slopes against erosion. If the depth to the sliding surface is greater than 0.5 m, then bio-engineering techniques should only be carried out in conjunction with other slope stabilisation techniques (e.g. retaining walls).

What are the best bio-engineering techniques?

Location	Technique	Advantages	Disadvantages
Cut slope in soil Road edge or shoulder in soil	Grass planting in lines, using rooted slips.	Rapid and complete surface cover.	Requires a soil slope without too many stones. Slow to establish on hard cut slopes.
Cut slope in mixed soil and rock	Direct seeding of shrubs and trees in crevices.	The best way to establish vegetation on rocky slopes.	Slow to provide a coverage good enough to resist erosion.
Fill slopes and backfill above walls	Brush layers using woody cuttings from trees or shrubs.	Instant physical barrier that interrupts runoff. Stronger than grass. Often successful on stony debris.	Can only be installed on slopes of 1V:1.25H or less, on unconsolidated materials.
Large and less stable fill slopes	Truncheon cuttings (big woody cuttings from trees).	Relatively strong plant material on slopes that are still unstable; withstands damage from moving debris.	Takes a long time to establish a complete cover. Needs a lot of planting material.
Gullies or seasonal stream channels	Live check dams using woody cuttings of trees.	Low cost, flexible structures to reduce erosion where water flow is concentrated.	Not as strong as check dams of gabion or masonry. Require careful supervision.
Other bare areas	Tree planting using potted seedlings from a nursery.	Allows a long term forest mix of trees to be restored.	Takes a long time to establish a complete cover. Seedlings are vulnerable to grazing for a few years.

What are the materials for these techniques?

Grass slips are small sections of a grass plant, made by splitting up a large clump. The stems are cut down to a height of 100 to 200 mm and the roots cut back to 40 to 80 mm. There should be 2 or 3 stems per slip.

Woody cuttings are taken from the branches of certain types of small trees. They are cut to be between 450 and 600 mm long, and the diameter should be between 20 and 40 mm in diameter. Shoots and leaves are trimmed off. For live check dams, cuttings are needed that are 2 metres in length.

It is very important that plant materials for bio-engineering are kept cool and damp when they are being moved and prepared.

How is grass planting done?

Grass slips are planted in lines across the slope. The best results usually come from lines that are at 45° to the maximum slope. Start from the top and work downwards.

Mark out the lines on the slope and then plant the grass slips to the original depth and gently firm the soil back around them.

How is brush layering done?

Mark out horizontal lines every 2 metres down the slope. Start from the bottom and work upwards.

Dig shallow trenches along the lines, 350 to 450 mm wide.

Lay the cuttings across the trenches with the bottom inwards and 80 to 100 mm of the top protruding from the slope. The cuttings should be 50 mm apart. Place a small amount of soil over the cuttings and then lay another line of cuttings. Replace all the soil and firm it down gently.

How are potted tree seedlings planted?

A hole is dug that is at least 300 mm in diameter and 300 mm deep. The pot is removed from the seedling and the seedling is planted in the hole, with care taken to fill soil gently but firmly around the root mass. This is repeated at 1.5 metre centres across the slope.