Low Cost Slope Stabilisation

Tim Hunt

Scott Wilson (Thailand)
What do we mean by low cost?

- Optimum use of low-skilled labour
- Maximum use of locally available materials
- Logical approach to design
- Use of local road maintenance contractors

This will be illustrated by the work carried out under the SEACAP 21 project in Laos
SEACAP 21 was part of the South East Asia Community Access Programme (SEACAP) funded by the UK’s Department for International Development (DFID). The project commenced in 2006 and was completed in 2009.

The Client was MPWT.

The project was carried out by Scott Wilson in association with LCG and SD & XP.
- SEACAP 21/001. Slope stabilisation trials on Road 13N and Road 7

- SEACAP 21/002. Feasibility study for a national programme to manage slope stability

- SEACAP 21/003. Mainstreaming slope stability management into National University of Laos and MPWT

- SEACAP 21/004. Training programme in landslide management
What was the project trying to achieve?

The objectives were:

- To use best-practice appropriate slope stabilisation methods using 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 by means of workshops, manuals, specifications and training
- Laos is about 90% the size of New Zealand
- Located between Thailand and Vietnam
- Population 6.3 million
- 75% hilly or mountainous
- 50% forested

- Project area about 250km north of Vientiane
- Mountainous terrain from 450m to 1450m elevation
- Annual rainfall in excess of 2000mm
Typical below-road failure
Typical above-road failure
Typical through-road failure
13 stabilisation sites eventually chosen comprising a mix of failure types.

Phase 1
- Those sites requiring mainly bio-engineering measures to prevent further instability. This comprised 3 sites, the work carried out just prior to and during the onset of the 2007 wet season.

Phase 2
- Those sites requiring mainly geotechnical measures to prevent further instability. This comprised 10 sites, the work carried out mainly during the 2007/08 dry season.
### SEACAP 21 PROGRAMME

<table>
<thead>
<tr>
<th>Task</th>
<th>06</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning &amp; Inception</td>
<td></td>
<td></td>
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<tr>
<td>Design &amp; Documents</td>
<td></td>
<td></td>
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<tr>
<td>Approvals &amp; Bid</td>
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<td>Construction</td>
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<tr>
<td>Manuals &amp; Training</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Phase 1**: Red
- **Phase 2**: Green
ROAD 13N, Km 316.6: EXISTING FAILURE
Shifting cultivation on slope above failure may have affected slope hydrology.

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°.

Slope below road destabilised by large volume of debris tipped in emergencies.
ROAD 13N, Km 316.6: PROPOSED TREATMENT

- Compacted backfill planted with brush layers
- Tree planting around head
- Trimming of head scar
- Dense planting with diagonal lines of grass
- 3-m gabion revetment
- Re-instated side drain
- Remove loose debris
- Tree planting around head

Scott Wilson
Phase 1 Construction
Phase 2 Construction

Km 242.6
Earthworks and Structures
- Construction Issues

- Safety
- Spoil disposal
- Wall foundations
- Masonry walls
- Gabion walls
- Backfill
- Others
Removal of spoil
Failure plane

DCP testing
Mortared masonry construction
Backfill density testing

Compaction using pedestrian roller
Access track construction

Stage construction
Incomplete walling
Retaining wall - front elevation

Estimated dimensions in contract drawings

Shape as constructed

Original ground level
Slope Maintenance Site Handbook

Slope Maintenance Manual
Slope Maintenance Site Handbook
Slope Maintenance Site Handbook

- Written for site staff: technicians, supervisors etc
- English and Lao language
- A5 size, 70 pages, illustrated mainly with photographs
- Structured around the MPWT’s MACs
- Definition of Maintenance for Slopes
- Routine Maintenance of Slopes
- Emergency Maintenance of Slopes
- Rehabilitation and Improvement
1.2 Routine Site inspections

Why is it necessary to carry out routine site inspections?

There are comparatively few occasions when a large-scale failure of a slope or wall occurs without some early warning. In most cases (except for minor slips), there are usually warning signs.

What should I look out for?

Check the reasons why the drainage system is damaged or cracked. Do the cracks in the roadside drain extend across the road? Is the damage being caused by differential movements? Are the roadside drains being blocked regularly in a particular location? Is the slope above/below moving?

Check the retaining walls and slopes above and below the road on foot. Are they in good condition? Are movements taking place? Are there any worrying signs of unclue erosion or ravelling occurring?

What if the situation looks serious?

Report it to your supervising engineer. As best as you can, fill in a Landslide or Wall Report (see Section 5).
2.2 Erosion

What should be done if erosion is occurring?

Erosion taking place below the road is usually due to a concentrated flow of water from the road finding its way onto an erodible slope or gully. This often happens when the roadside drains have been blocked, or where the surface water is able to run down the lower side of the road. In these cases the blockage should be cleared, or a temporary earth bund constructed on the edge of the road to prevent the water from running down the slope. The problem also often occurs at the lower end of road supporting retaining walls. Eventually, the temporary earth bund should be replaced with a concrete upstand or kerb, to make sure that the water flow is redirected to a suitable location where it will not cause further erosion.

Erosion also commonly takes place in streams and gullies above and particularly below the road. In this case it might be necessary to construct a check dam or non-erodible lining, for example out of gabion or mortared masonry.

If the erosion is occurring above the road, then the source of the water needs to be determined. If it is the result of human activity, for example rice irrigation, housing etc, then the appropriate village authorities should be notified. If it is the result of natural causes, then bio-engineering techniques may solve the problem (see Section 4.4).

2.5 Vegetation management

Why is it necessary to manage vegetation?
The roadside slopes are mainly covered in vegetation. This helps to control erosion on soil slopes. However, the plants grow rapidly and need to be controlled regularly to stop them from extending out into the road. They become dangerous to traffic when they hide pedestrians, cause vehicles to be driven in the middle of the road or reduce drivers’ sight lines.

How should vegetation be controlled?
Plants should be cut back several times a year, according to need. Smaller plants can be cut with a machete. Plants must never be pulled or dug out by roots, and must never be burnt.

Where should the material that has been cut be placed?
Ensure that the cut plant material is placed in locations where it won’t be washed into the drainage system during heavy rain; for example on a flat area on the opposite side of the road. The removed material should be left in tidy piles but not burnt.

What else needs to be done?
Ask the labourers to look out for any damage or cracks in the ground and point these out to you. This may be an indication of instability, especially on the lower side of the road. Any such damage or cracks will need to be repaired under Rehabilitation or Emergency Maintenance. Make sure that the labourers do not light fires to burn vegetation, especially at the end of the day.
3.3 Temporary drainage measures

*Why are temporary drainage measures required?*

If the failure is located below the road, immediate steps should be taken to prevent water from the road surface or drainage system from entering the crest of the failure and creating further instability. It may be necessary to dig catchpit bypass channels to prevent roadside drainage water from entering a culvert. The upstream roadside drain may need to be blocked and water directed across the road away from the failure by an earth bund to a more suitable temporary discharge point.

If the failure is located above the road with debris blocking the roadside drain, then immediate measures should be taken to prevent the water from crossing the road and discharging at random down the valley slope.
4.2 Construction of new walls

*What are the main types of walls?*

There are three main types of wall constructed in Laos: masonry, gabion and reinforced concrete. Masonry walls can be composite or fully mortared.

Retaining walls may be constructed below or above the road. They retain the ground behind them. Revetments may also be constructed above the road.

From the road, Revetments and Retaining Walls can both look the same. The difference is that Revetments are very thin (usually only 300mm thick) and only prevent erosion and shallow sliding from occurring at the base of the slope. They are not very strong, and they do not act as retaining structures.
What are the advantages and disadvantages of the main types of walls?

<table>
<thead>
<tr>
<th>Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite masonry</td>
<td>Fairly cheap.</td>
<td>No flexibility.</td>
</tr>
<tr>
<td>Dry stone panels</td>
<td>Very permeable.</td>
<td>Not as strong as full mortared masonry.</td>
</tr>
<tr>
<td>Mortared masonry</td>
<td>Expensive.</td>
<td></td>
</tr>
<tr>
<td>Gabion</td>
<td>Flexible – good where founding conditions are variable.</td>
<td>May be too flexible for road supporting retaining walls.</td>
</tr>
<tr>
<td></td>
<td>Very permeable.</td>
<td>Usually requires geotextile on back face to reduce fines seeping through wall.</td>
</tr>
<tr>
<td>Cheaper than cemented masonry</td>
<td>Foundation may be softened by water percolating through wall.</td>
<td>Less durable than mortared masonry.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Required to construct if foundation uneven, although this can be overcome by using a mortared masonry layer at the base.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>More difficult to construct in curves in plan.</td>
</tr>
<tr>
<td>Reinforced Concrete</td>
<td>Very durable if good quality construction</td>
<td>Most expensive option.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No flexibility – should always be constructed on good foundations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No permeability; weep holes should always be provided.</td>
</tr>
</tbody>
</table>

From considerations of cost, durability, appearance and strength, cemented masonry walls are generally recommended except where foundation conditions are soft or expected to move over time. In those cases, gabion walls are recommended.

What wall shape should be used?

The Slope Maintenance Manual discusses a number of wall shapes and their advantages and disadvantages. For simplicity, two basic wall shapes are recommended – one for mortared masonry walls and the other for gabion walls.

Gabion walls. Remember that gabion walls are permeable to water. Any water permeating through the gabions down to foundation level must be allowed to escape easily. This means that any surplus spoil placed in front of the wall during excavation must be removed to prevent ponding.

Foundation level. Most small scale wall foundation levels can be determined by visual inspection. The use of a Dynamic Cone Penetrometer (DCP) may help in determining a suitable foundation level and further information on this device is given in the Slope Maintenance Manual.

The DCP comprises an 8 kg hammer falling a distance of 575 mm onto a rod to which a 20-mm diameter hardened steel cone is attached. The number of blows to drive the cone a measured distance into the ground gives an indication of its strength.
Bio-engineering

**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 control erosion or 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 described in section 4.3.

**What are the best bio-engineering techniques?**

The table below summarises the best available techniques.

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

**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.

**Truncheon cuttings** are made from the branches of large trees. They should be about 2 metres in length and 50 to 80 mm in diameter.

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

**Which species of plants should be used?**

The table below lists the plants that have been shown to be successful for bio-engineering work in Laos.

<table>
<thead>
<tr>
<th>Species for grass slips</th>
<th>Species for woody cuttings</th>
<th>Species for direct seeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nyar khaem, dok khaem (broom grass)</td>
<td></td>
<td>Khlieckdong</td>
</tr>
<tr>
<td>Nyar kha</td>
<td></td>
<td>Koun</td>
</tr>
<tr>
<td>Nyar phaek</td>
<td></td>
<td>Khatin</td>
</tr>
<tr>
<td>Nyar khaem lao (2 different species)</td>
<td></td>
<td>Tiou dam</td>
</tr>
<tr>
<td>Nyar phaek, fek hom (vetiver)</td>
<td></td>
<td>Pohou</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hookatal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phak nao</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Som poi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phak thon</td>
</tr>
</tbody>
</table>

Almost any type of tree can be brought from a nursery as a potted seedling.
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 truncheon cuttings planted?

Use a crowbar to make a vertical hole that is about 20 mm wider than the cutting and at least 1 metre deep. Place the cutting in the hole and gently fill around it with loose soil. Truncheon cuttings are usually planted 1 metre apart on deep debris slopes.

Finishing works

What finishing works are necessary?

Check all construction and bio-engineering details. Make sure that they have been completed as instructed. If necessary, instruct repairs.

Finally, the site should be inspected during or immediately after a period of heavy rain to see if the run-off is going where it is intended and without any erosion, and if not, to carry out any additional works to ensure that it does.

Before and after treatment

Road 13 North, km 316. A revetment wall and various types of bio-engineering works were used to protect the slope.
## LANDSLIDE REPORT

### Location (road and km):

<table>
<thead>
<tr>
<th>Situation</th>
<th>Material</th>
<th>Blockage</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above road</td>
<td>Rock</td>
<td>Whole road</td>
<td>Whole road</td>
</tr>
<tr>
<td>Below road</td>
<td>Debris</td>
<td>Part of road</td>
<td>Part of road</td>
</tr>
<tr>
<td>Through road</td>
<td>Soil</td>
<td>Side drain only</td>
<td>Side drain only</td>
</tr>
</tbody>
</table>

### Geometry of slipped area

<table>
<thead>
<tr>
<th>Length (m perpendicular to road)</th>
<th>Original slope angle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Width (m parallel to road)</th>
<th>Failure angle</th>
</tr>
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</tbody>
</table>

### Depth (m estimated)

- 1-3 m

### Estimated volume (L x W x D)

- 3000 m³

### Topography

- Associated retaining wall

### Sketch of failure/additional notes

### Probable cause of failure:

- Small slides in cut slope seem to have occurred due to cultivation and runoff from plantation immediately above. These blocked the side drain, overflow from drain ran across road and saturated steep debris slope below, causing it to slump down. Water also seared edge of road.

### Consequences if not done:

1. Debris will continue to slump down on lower side, leaving a higher and higher backscarp.
2. Water will go on scouring the edge of the road so that the backscarp eats back into the road.
3. The cut slope will keep failing so that the side drain is constantly getting blocked.
Slope Maintenance Manual
Slope Maintenance Manual

- Written for road management professionals: engineers.
- English and Lao language versions.
- A4 size, 108 pages, illustrated with drawings & photographs.
- Covers all relevant aspects of site inspection, design and construction.
Technical Specifications

- Complete technical specifications for slope stabilisation and protection.
- English and Lao language versions.
- Based on international experience and best practices.
- Tested through SEACAP 21 trials and modified accordingly.
Instability

- Failure in hill slope but not cut slope: Debris may slip on to side drain or road
- Failure in cut slope and hill slope: Debris will block drain and may block road
- Failure in cut slope only: Debris will block drain and may partially block road
- Erosion of cut slope surface: Debris will block drain and may block road
- Erosion of fill slope surface: Part of the road may eventually be lost
- Line of original ground
- Cut slope
- Side drain
- Original hill slope
- Deep failure in original ground below road: A whole section of road will eventually be lost, and will be difficult to replace
- Failure in fill slope only: Part of the road will be lost
- Failure in fill slope and original valley slope: Road is seriously endangered
- Failure in original valley slope only: Headward retreat will endanger road
- River undercutting: Zone liable to damage from river bank erosion

Original valley slope
Diagnosis of rock slope instability

Rock slopes: typical maintenance problems
(right) Rock slopes: failure mechanisms

- Unstable material in upper part of slope
- Unstable rock overhang
- Tree roots loosening surface
- Loose blocks on surface
- Failure due to adverse joints
- Rockfall material blocking drain

- Planar failure in rock in which a discontinuity "daylights" the slope face
- Wedge failure on two intersecting discontinuities with a line of intersection which "daylights" the slope
- Toppling failure in hard rock with slabs or columns defined by discontinuities that dip steeply into the slope
- Circular failure in overburden soil, waste rock or heavily fractured rock with no identifiable structural pattern

Rock slope toppling failure
Instability in walls

Predominantly overturning movement to wall: Movement may create cracks in road surface and wall collapse; may require underpinning at toe of wall of total replacement on more stable foundation.

Weakening of foundation at toe due to erosion/scour of softening/weathering.

Predominantly horizontal sliding movement to wall: Movement may crack/block drain; repair/replacement increased (e.g. base width increased, shear key constructed) or driving forces reduced (e.g. slope regraded, slope drainage improved).

Deep failure in original ground beneath one or both walls: Differential movements may cause wall collapse; repair/replacement ineffective unless wall foundation taken down to stable ground below slip surface.
Figure 3-1: Decision-making process for site assessment and problem diagnosis

- Routine or emergency inspection (3.2)
  - Slope problem found?
    - No
    - Check again next time
    - Yes
      - Detailed site inspection (3.3.2)
      - Understanding of problem
      - High
        - Undertake intermediate (3.4.1) or detailed (3.4.2) geotechnical ground investigation and/or slope movement monitoring (3.5)
      - Low
        - Design remedial measures (5)
  - Moderate
    - Implement remedial works (6)
Prioritisation by hazard and risk

<table>
<thead>
<tr>
<th>Actual or expected consequences</th>
<th>Risk ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road completely lost (or road subsidence greater than 1m) or occupied buildings damaged or destroyed</td>
<td>✔</td>
</tr>
<tr>
<td>Road partially lost</td>
<td>✔</td>
</tr>
<tr>
<td>Road completely blocked</td>
<td>✔</td>
</tr>
<tr>
<td>Road subsidence less that 1 metre</td>
<td>✔</td>
</tr>
<tr>
<td>Road partially blocked</td>
<td>✔</td>
</tr>
<tr>
<td>Productive agricultural or forest land lost or destroyed</td>
<td>✔</td>
</tr>
<tr>
<td>Walls damaged or slope drainage blocked or damaged</td>
<td>✔</td>
</tr>
<tr>
<td>Roadside drainage damaged or blocked</td>
<td>✔</td>
</tr>
<tr>
<td>Continued erosion without destroying vegetation cover</td>
<td>✔</td>
</tr>
</tbody>
</table>

**Ranking and priority**

1. Top priority, emergency measures required immediately; buildings may need to be evacuated.
2. High priority; realignment may be necessary.
3. Moderate priority, but some temporary remedial measures are required immediately, such as slip debris clearance, emergency road signing etc.
4. Low priority, but some actions are required quickly, such as slip debris clearance.
5. Least priority, but should be tackled as soon as possible under routine maintenance.

<table>
<thead>
<tr>
<th>Hazard ranking</th>
<th>Soil/highly weathered rock or colluvial slope</th>
<th>Rock slope, fresh to moderately weathered</th>
<th>Wall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height (m)</td>
<td>Angle (deg)</td>
<td>Height (m)</td>
</tr>
<tr>
<td>High</td>
<td>&gt; 15</td>
<td>&gt; 35</td>
<td>&gt; 12</td>
</tr>
<tr>
<td>Moderate</td>
<td>5-15</td>
<td>25-35</td>
<td>7-12</td>
</tr>
<tr>
<td>Low</td>
<td>&lt; 5</td>
<td>&lt; 25</td>
<td>&lt; 7</td>
</tr>
</tbody>
</table>

Notes: For slopes, use height or angle to derive highest category
Table based on average conditions
Determination of treatment
Engineering Solutions

1. Erosion of cut slope surface: Improve drainage, construct check dams
2. Failure in cut slope only: Reduce slope angle, construct wall, improve drainage
3. Failure in hill slope but not cut slope: Reduce slope angle, construct wall, improve drainage
4. Failure in cut slope and hill slope: Reduce slope angle, construct wall, improve drainage
5. Erosion of fill slope surface: Improve drainage, construct check dams
6. Failure in fill slope only: Replace, construct wall
7. Failure in fill slope and original valley slope: Replace fill, construct wall, improve drainage
8. Failure in original valley slope only: Replace fill, construct wall
9. Deep failure in original ground below road: Reduce slope angle, construct toe berm, consider realignment, consider temporary re-paving only
10. River undercutting: Construct river training works, slope protection
Engineering solutions are given for the following categories

- Resolving problems of existing walls
- Soil slope stabilisation with walls
- Drainage improvements
- River training and scour protection
- Bio-engineering techniques
- Rock slope stabilisation

Example: retaining wall options
Designs are discussed for:

- Walls
  - Composite masonry
  - Mortared masonry
  - Gabion
  - Other types
- Revetments
- Catch walls
- Bio-engineering

Example: gravity wall design options
Designing solutions

<table>
<thead>
<tr>
<th></th>
<th>Profile 1</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Height (H) m</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Base Width (B) m</td>
<td>1.6</td>
<td>2.1</td>
<td>2.6</td>
<td>3.1</td>
<td>3.6</td>
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<tr>
<td>Max Pressure kN/m²</td>
<td>30</td>
<td>50</td>
<td>70</td>
<td>90</td>
<td>110</td>
<td>130</td>
<td>150</td>
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<td>2.6</td>
<td>3.1</td>
<td>3.6</td>
<td></td>
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</tr>
<tr>
<td>Max Pressure kN/m²</td>
<td>40</td>
<td>60</td>
<td>90</td>
<td>120</td>
<td>150</td>
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Construction issues
Typical details: Masonry Retaining Wall
Typical details: Grass Planting

GRASS SLIP DETAILS
FULLY RAKED AND LEVELLED GRADE SYSTEM

GRASS PLANTING LINES (H)

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE STATED.
Typical details: Hardwood Cutting Techniques
Love your Nation, Maintain the Roads