SEACAP 21/001

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

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 and specifications

What were the constraints?

- Choice of sites
- Limited funds for construction
- Limited contractor capability
- Innovation

- **Project area about 250km north of Vientiane**
- **Mountainous terrain from 450m to 1450m elevation**
- **Annual rainfall probably more than 2000mm**

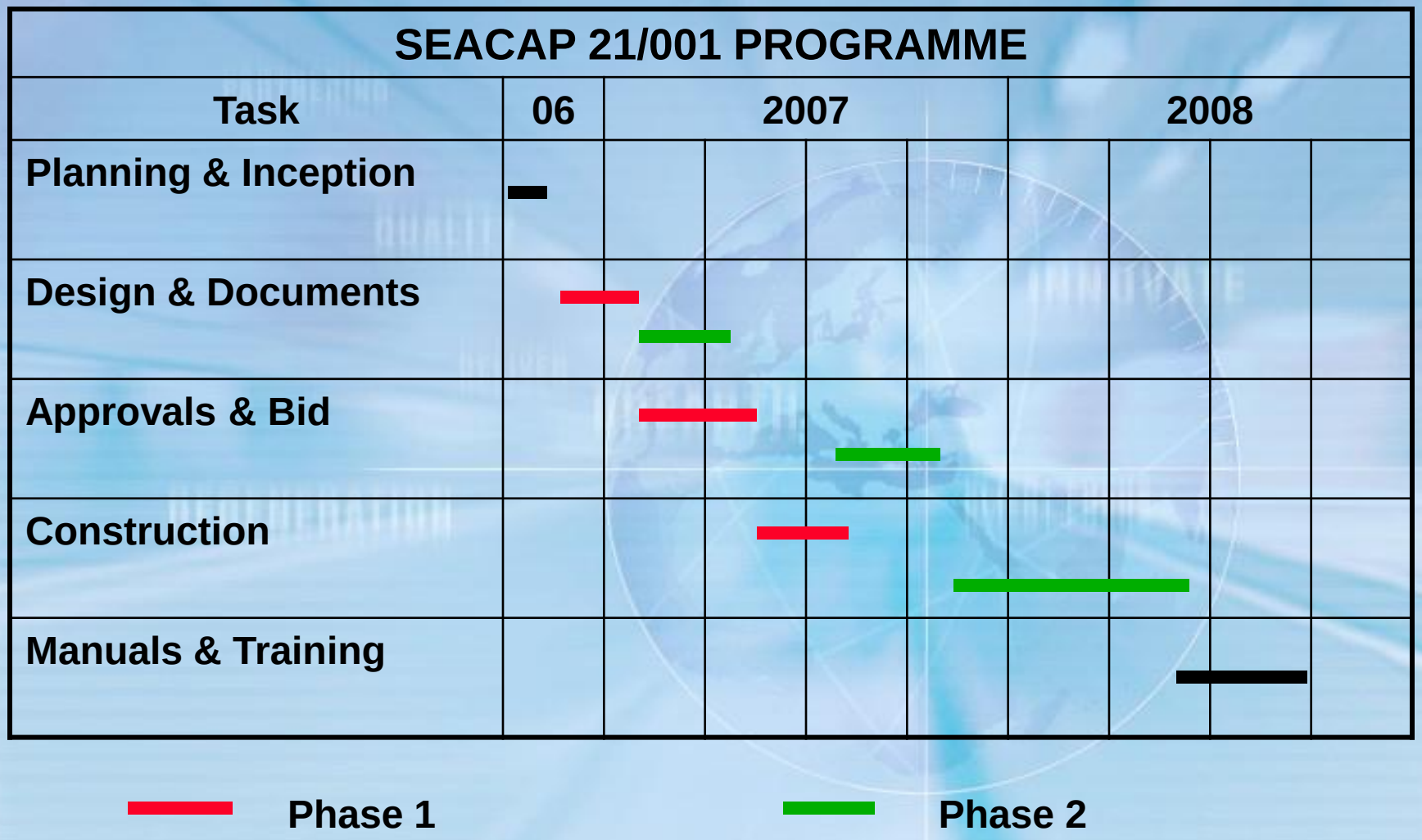
13 sites eventually chosen comprising a mix of failure types.

Phase 1

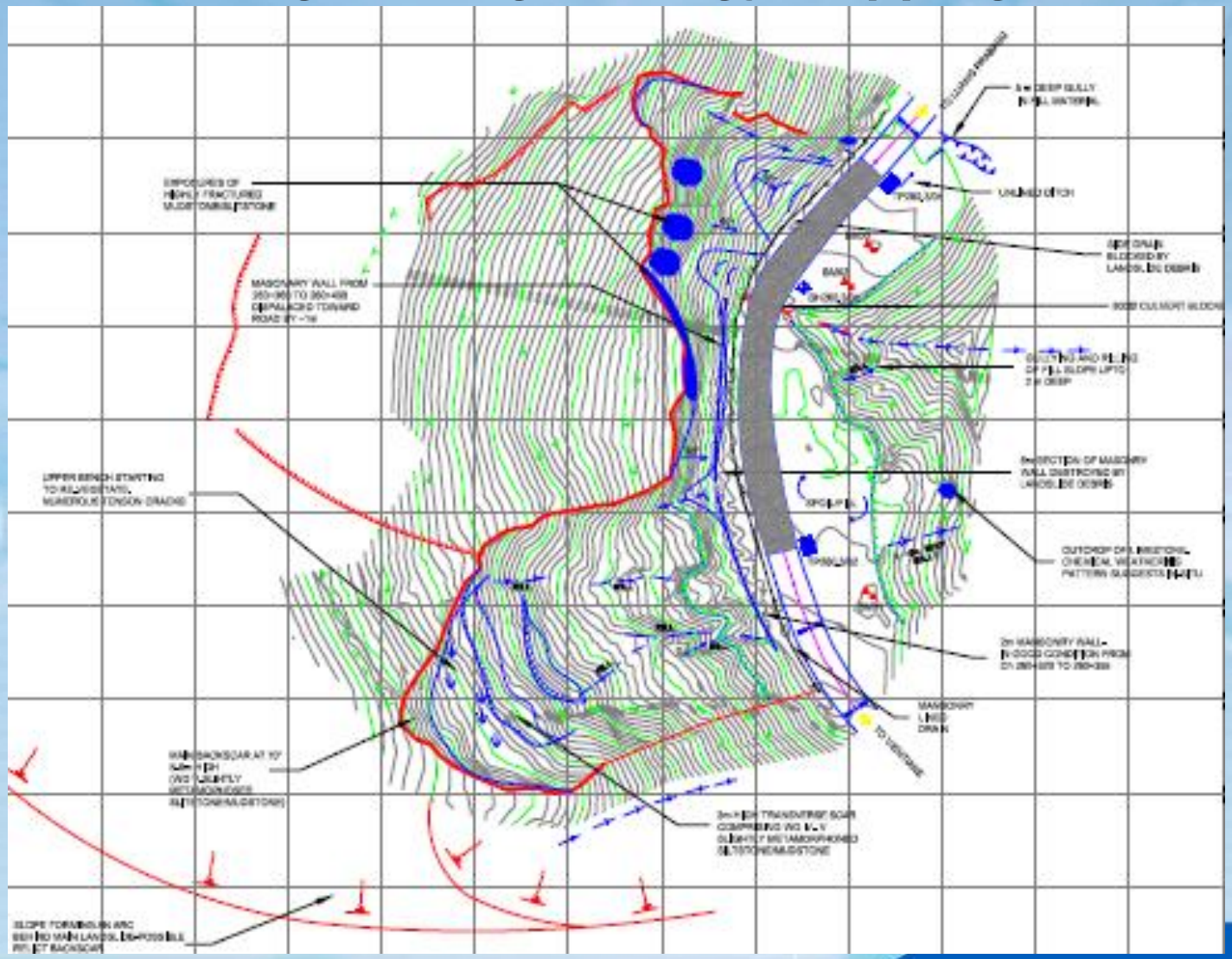
- Those sites requiring mainly bio-engineering measures to prevent further instability. This comprised 3 sites, the work carried out just prior to and during the onset of the 2007 wet season.

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 21/001 PROGRAMME
Task
06
2007
2008
Planning & Inception
Design & Documents
Approvals & Bid
Construction
Manuals & Training
Phase 1
Phase 2

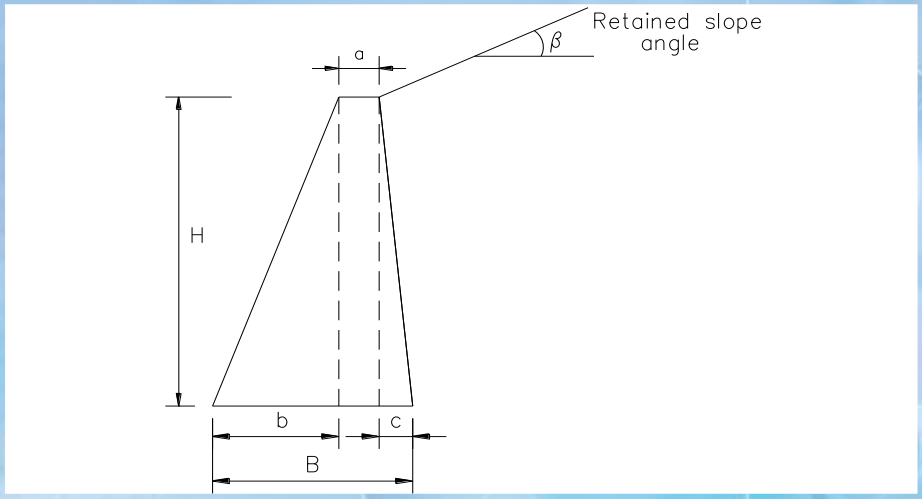
Engineering Geology Mapping



Ground Investigation

Design

Design Spreadsheet for Masonry Gravity Walls



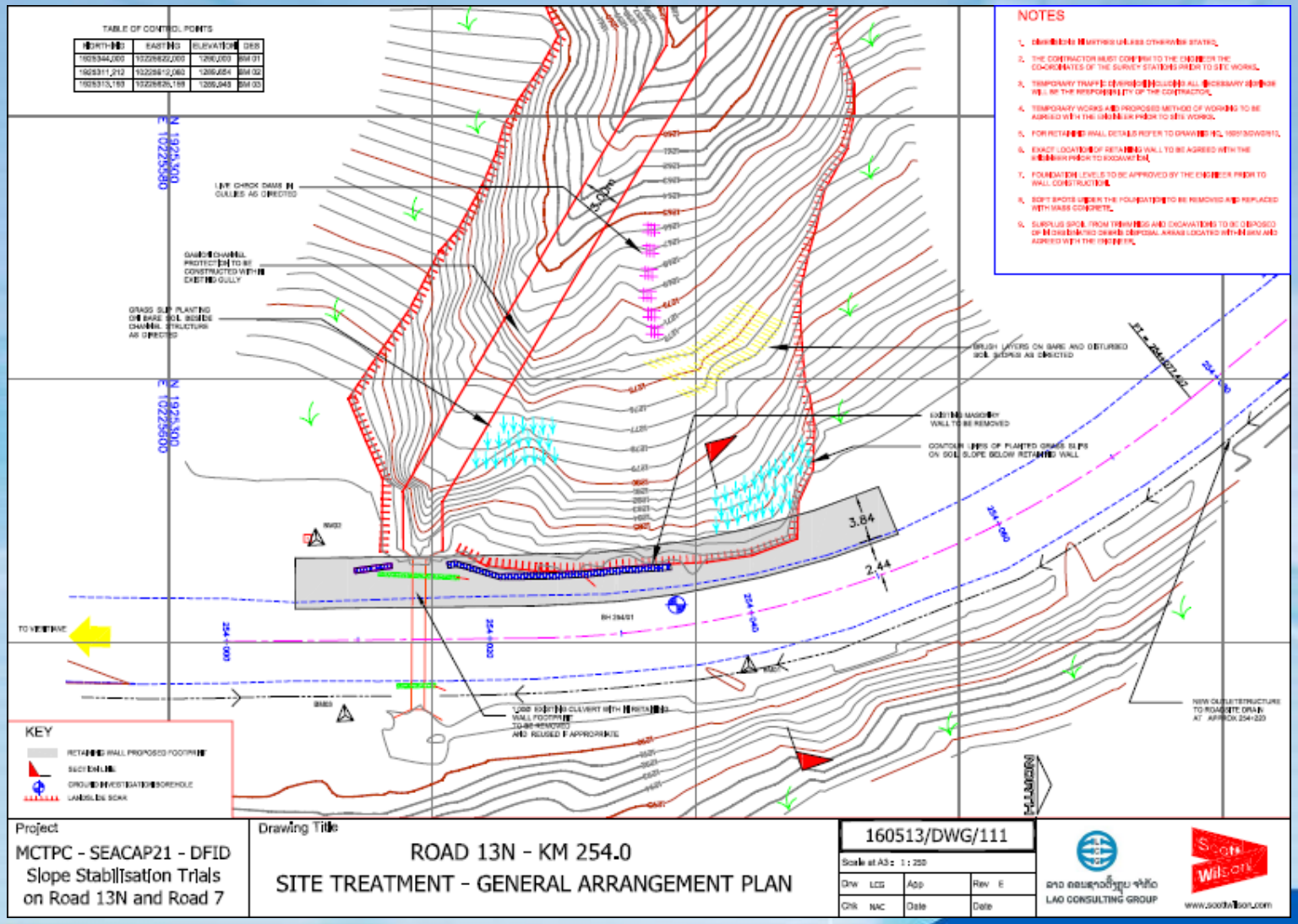
DENSITY OF WALL MATERIAL	22	kN/m^3		
PHI OF BACKFILL	30	ϕ	rad	0.523599
BACKFILL DENSITY	18	kN/m^3		
PHI OF BASE	20			
ACTIVE COEFF (Ka)	0.26			
Active Pressure	21	kN/m^2		
SURCHARGE	10	kN/m		
Back Slope Angle of Wall	95	α	rad	1.658063
WALL FRICTION	20	δ	rad	0.349066
SLOPE	0	β	rad	0

Calculation of Ka	
Ka	
$\sin^2(\alpha+\phi)$	0.67101
$\sin^2\alpha$	0.992404
$\sin(\alpha-\delta)$	0.965926
$\sin(\phi+\delta)$	0.766044
$\sin(\phi-\beta)$	0.5
$\sin(\alpha+\beta)$	0.996195

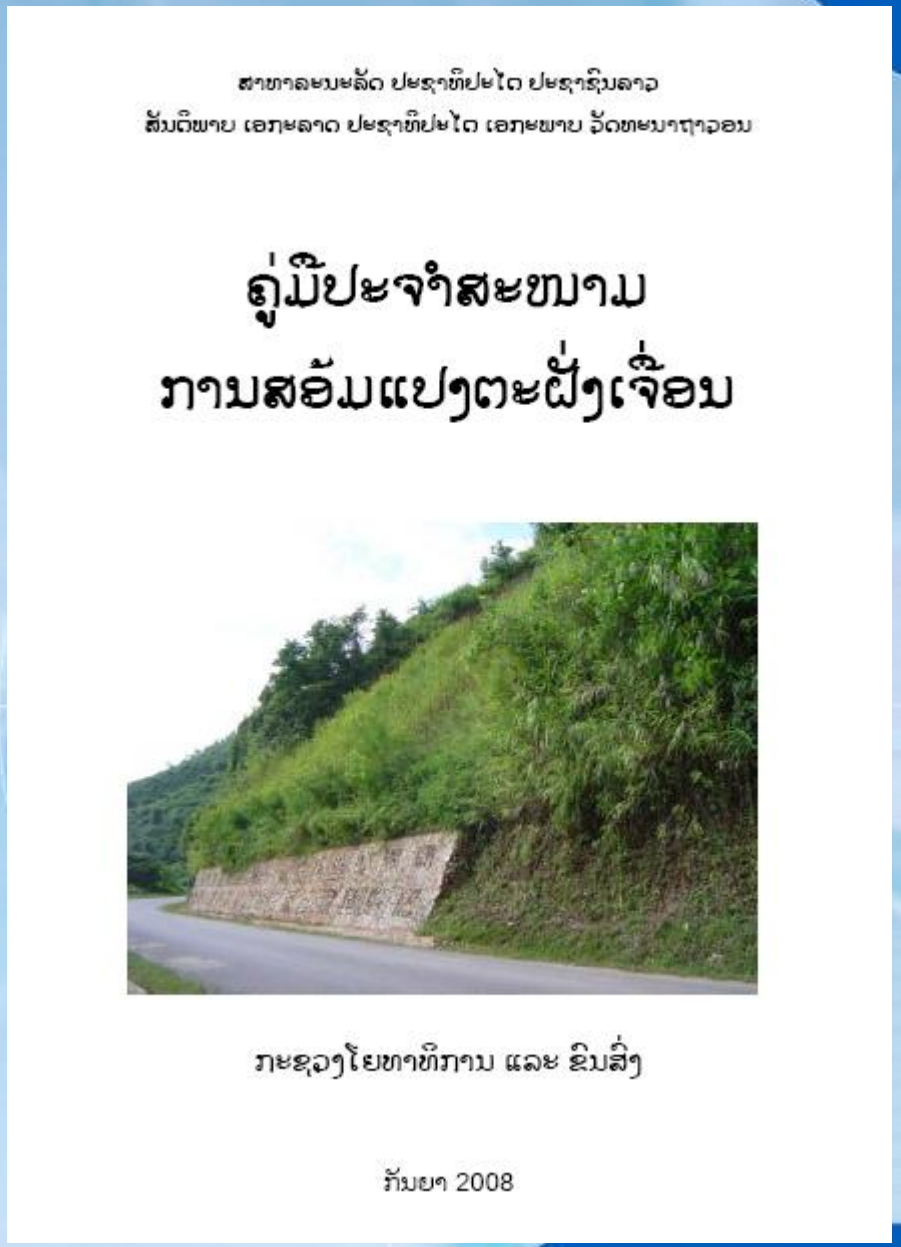
Section of Wall (in metres)

a	b	c	B	H
0.6	1.091	0.262	1.953	3

Construction drawings



SEACAP 21
Slope Maintenance Site Handbook



Slope Maintenance Site Handbook (1)

- Written for site staff: technicians, supervisors etc.
- English and Lao language versions
- A5 size, 30 pages, illustrated mainly with photographs
- Structured around the MPWT's Maintenance Activity Codes.

Slope Maintenance Site Handbook (2)

- Definition of Maintenance for Slopes
- Routine Maintenance of Slopes
- Emergency Maintenance of Slopes
- Rehabilitation and Improvement.

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.

Mortared masonry wall

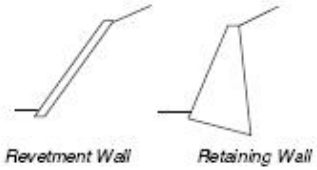
Composite masonry wall

Gabion wall

Reinforced concrete wall

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.



Revetment Wall *Retaining Wall*

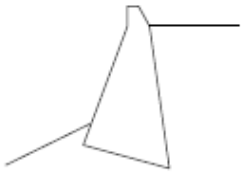
What are the advantages and disadvantages of the main types of walls?

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

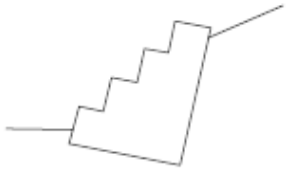
From considerations of cost, durability, appearance and strength, cemented masonry walls are generally recommended except where foundation conditions are soft or expected to move over time. In those cases, gabion walls are recommended.

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 cemented masonry walls and the other for gabion walls.



Mortared Masonry wall



Gabion wall

LANDSLIDE REPORT

Location (road and km):

Date of report: Reporter's name:

Situation		Material		Blockage		Failure	
Above road		Rock		Whole road		Whole road	
Below road		Debris		Part of road		Part of road	
Through road		Soil		Side drain only		Side drain only	

Geometry of slipped area		Topography	
Length (m perpendicular to road)		Original slope angle	
Width (m parallel to road)		Failure angle	
Depth (m estimated)			
Estimated volume (L x W x D)		Associated retaining wall	

Sketch of failure/additional notes:

Probable cause of failure:

Consequences if nothing done:

WALL CONSTRUCTION CHECKLIST – MAIN FEATURES	
Safety	**Done?**
Have traffic warning signs been placed beside the road?	
Have barriers been placed alongside the excavation to mark out its extent? Are these clearly visible at night?	
All walls	
Have precautions been taken to prevent surface water on the road from entering the excavation?	
If excavating into the hillside, has this been done in alternate bays and the wall constructed in short lengths to prevent hillside instability?	
Is the excavated material being removed to a safe location and not dumped down the slope?	
Has the excavation level been taken deep enough to ensure that the wall is adequately founded? (The use of a DCP may help in this regard).	
Mortared and Composite Masonry walls	
Does the stone being used meet the specification for durability, size and shape?	
Is there sufficient cement in the mortar to meet the specified strength?	
Is the mortar sufficiently fluid to ensure that all the voids between the stones are completely filled?	
Have the marker blocks at the top of the wall been properly bonded into the rest of the wall?	
Gabion walls	
Is there adequate drainage from the lowest point of the excavation?	
Does the gabion wire conform to the specifications?	
Do the gabion baskets contain a transverse mesh at 1.0m centres?	
Are the stones durable and angular and with a minimum dimension not less than the gabion mesh?	
Have all the stones been carefully and densely packed into the basket?	
Have horizontal wire trusses (10 SWG or 3.25mm dia wire) been installed at 0.33m centres during filling to reduce bulging?	
Have the gabion baskets been properly connected to each other using 12 SWG (2.64mm dia) wire?	
Have the gabion baskets been staggered, as in blockwork, and with some gabions placed front to back?	
Reinforced Concrete walls	
Has the steel reinforcement been properly cleaned?	
Is there the specified cover between the reinforcement and the shuttering?	
Has the shuttering been properly secured to prevent movement during concreting?	
Does the concrete mix conform to specification?	
Has the concrete been vibrated to exclude all voids?	

SEACAP 21
Slope Maintenance Manual

Slope Maintenance Manual

- Written for road management professionals: engineers
- English and Lao language versions
- A4 size, 110 pages, illustrated with drawings, photographs, typical details
- 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

Innovation?

- Approach to problem: site assessment, hazard ranking, ground investigation, design, construction
- Bio-engineering: several techniques
- Wall design and construction: masonry and gabion
- Drainage: roadside, wall, slope
- Manuals: Comprehensive manuals written in Lao and English