Steep Wall Liners

Luke Adams

Callum Browning

Tonkin+Taylor

Acknowledgement

This presentation is being delivered by just two people but has been developed with contributions from across T+T and refers to design principles developed by others outside of T+T both past and present.

We acknowledge these contributions and give this presentation in the interest of sharing knowledge.

Introduction

Why build a steep wall liner?

Risks, constraints and considerations

Design principles

Conclusions

Why, what, when and where?

- *Steep subgrade walls maximise extractive yield per area increasing return from quarry effort.*
- *Quarrying often undertaken to different standards with little consideration of landfilling.*
- *Large low angle side wall construction can require extensive subgrade fill and associated cost.*
- *Extends the life of a landfill instead of having to site and develop a new site with increased risk.*
- *Can reduce stress on liner components and inclined leachate riser pipes.*
- *Not suited to all subgrade types and groundwater environments.*

Risks, considerations and constraints

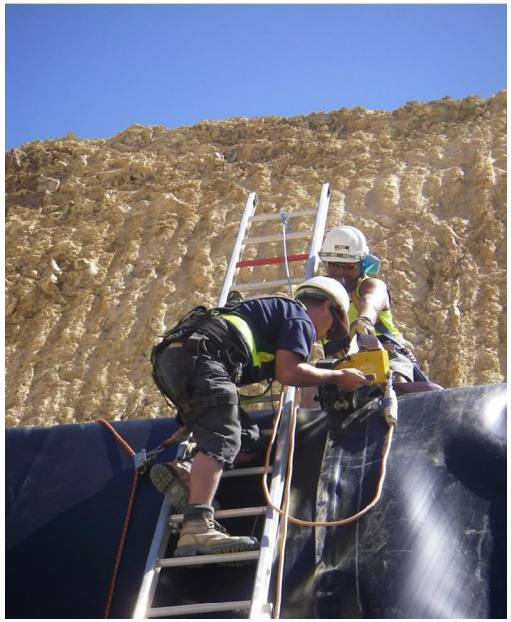
Subgrade conditions

- Soil or rock
- Smooth or rough
- Wet or dry
- Stable or unstable
- Natural or disturbed

Liner conditions

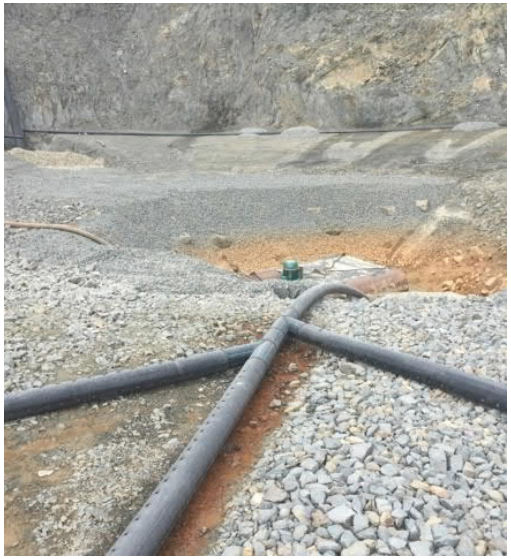
Installation safety

Constructability



Pit water management

- Prior to lining
- During construction
- During filling



Post lining

- Construction verification
- Auditing/Approval timeframes
- Temporary buttressing
- Waste composition and filling timeframe

Tonkin+Taylor

Design Principles

Subgrade preparation

Earthen vs geosynthetic liners

Construction staging

Progressive construction

Slope stability

Interface friction and down drag

Waste mass stability

Geosynthetics restraint

Barrier protection requirements

Subgrade preparation

Adapting existing quarry void vs purpose designed excavation

Determining safe batter angle

Changes in geology

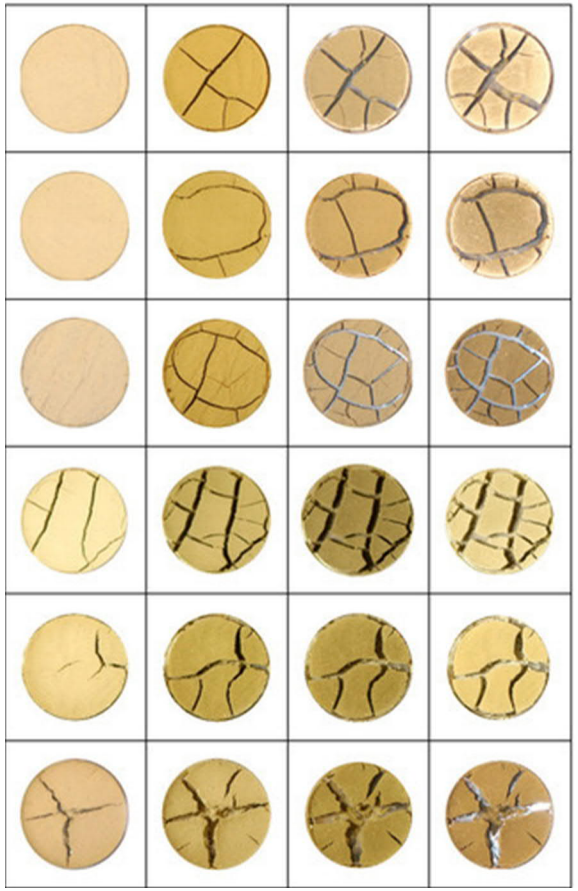
Bench widths to manage rock falls and liner deployment

Slope improvement works options (Clay, no-fines concrete, shotcrete, mesh, rock bolts etc.)

Time of exposure / wall collapse / rebuilding wall sections

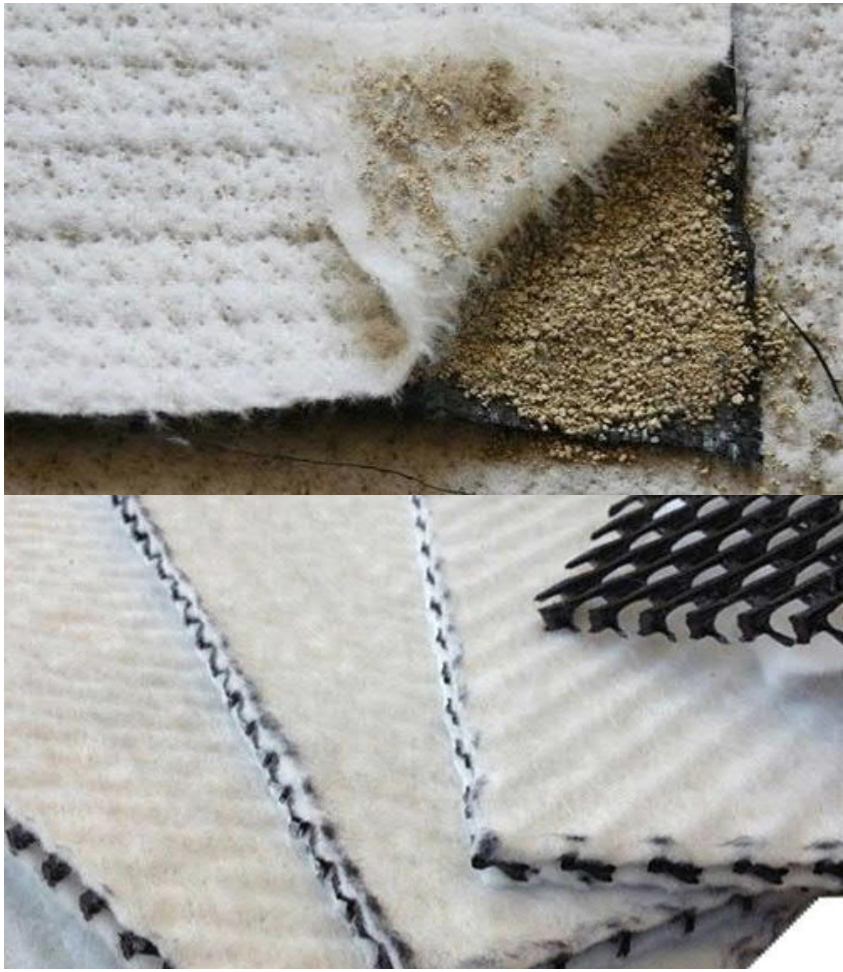
Earthen liners

- Earthen liners are an older proven technology, simpler to construct and most CQA testing is fast turn around.
- Management of CCL moisture and undrained vs. drained conditions
- Transition to drained conditions is inevitable.
- Control of desiccation in liner can be controlled through building overthick or a protection layer.



Geosynthetic liners

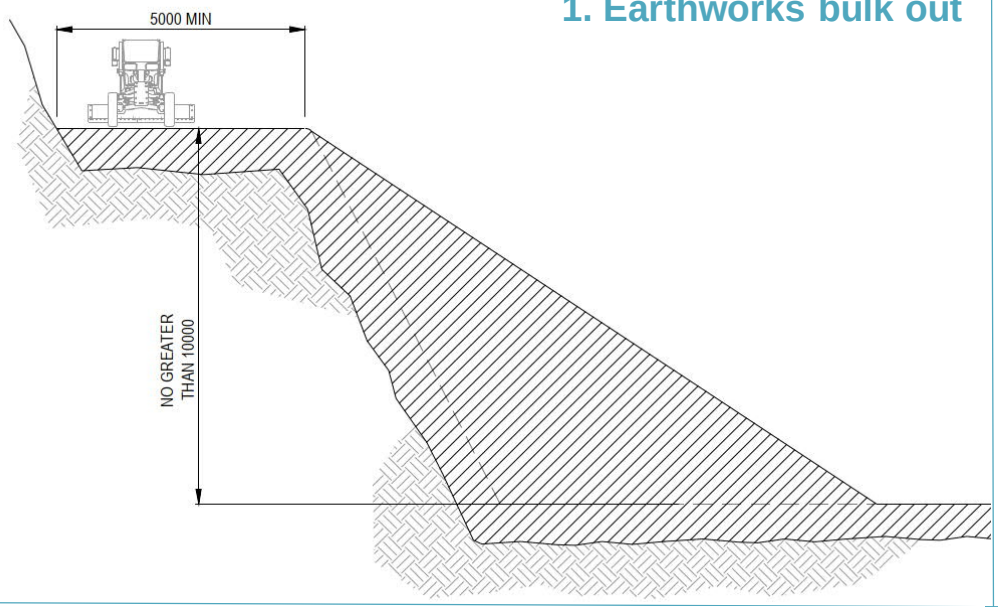
- Geosynthetic liners will almost always contain some earthen component beneath liner such as attenuation layer or concrete/shotcrete/NFC to smooth out irregularities in the subgrade wall surface.
- Geosynthetic liners can be quicker to install.
- Liner profile typically much thinner which can deliver more airspace.
- High performance materials can be less robust and small tolerance if damaged compared to CCL.
- Leachate aggregate can be replaced with drainage geocomposite on steep side walls.
- Ensuring geosynthetic layers perform as designed is the main challenge facing steep wall liner design.



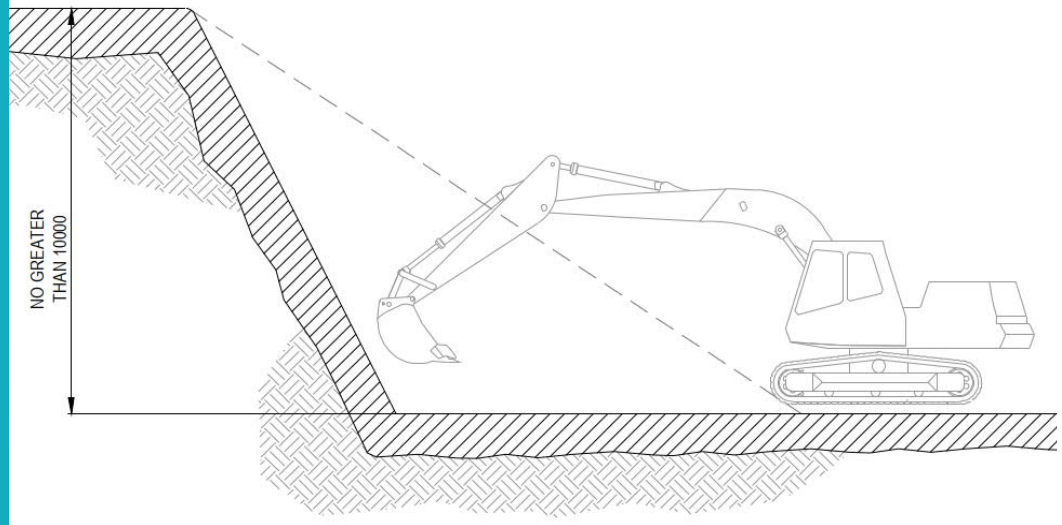
Construction staging

Tonkin+Taylor

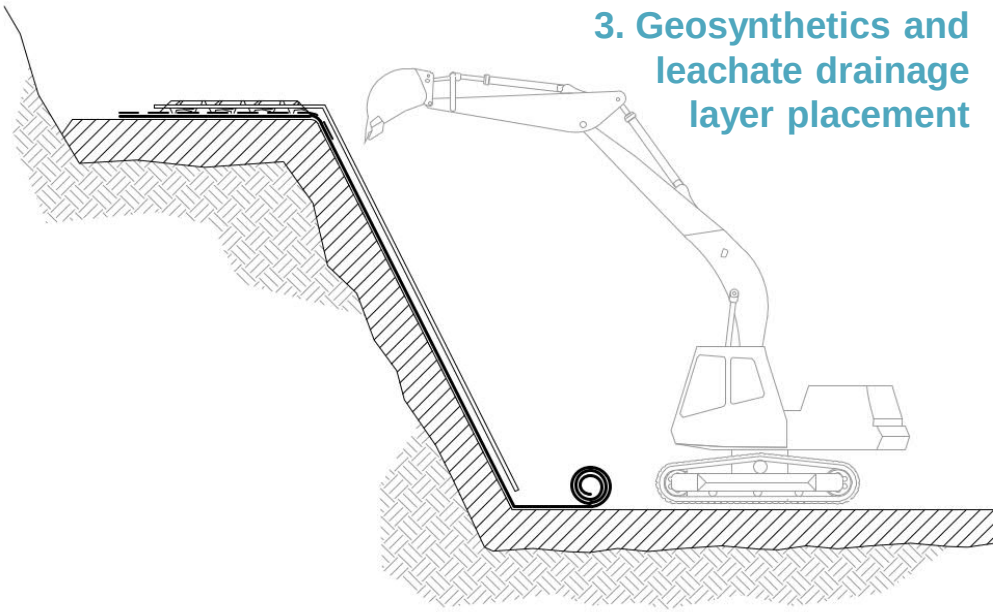
1. Earthworks bulk out



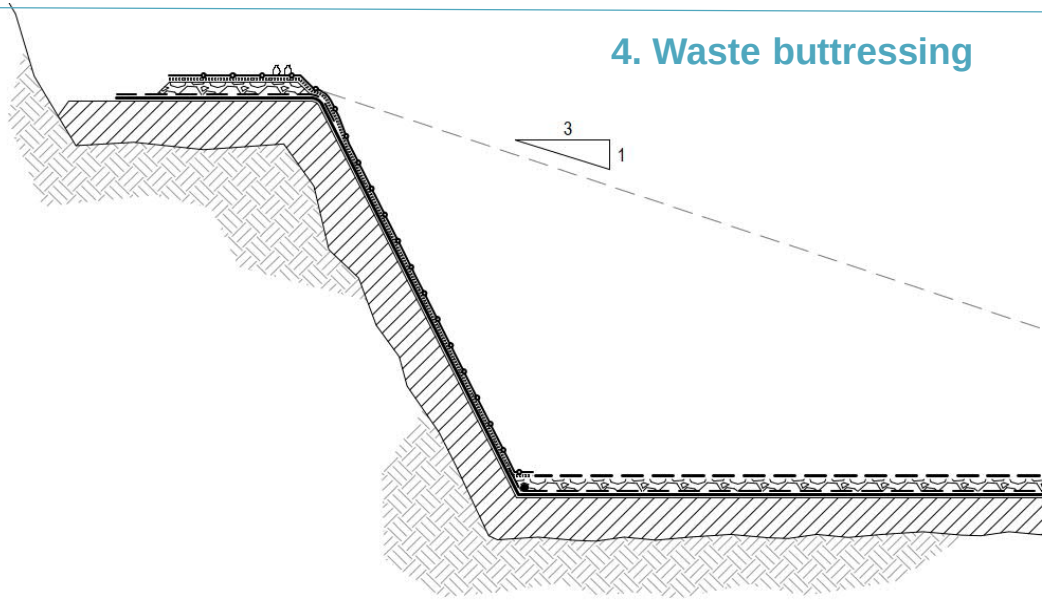
2. Earthworks trim



3. Geosynthetics and leachate drainage layer placement



4. Waste buttressing



Tonkin+Taylor

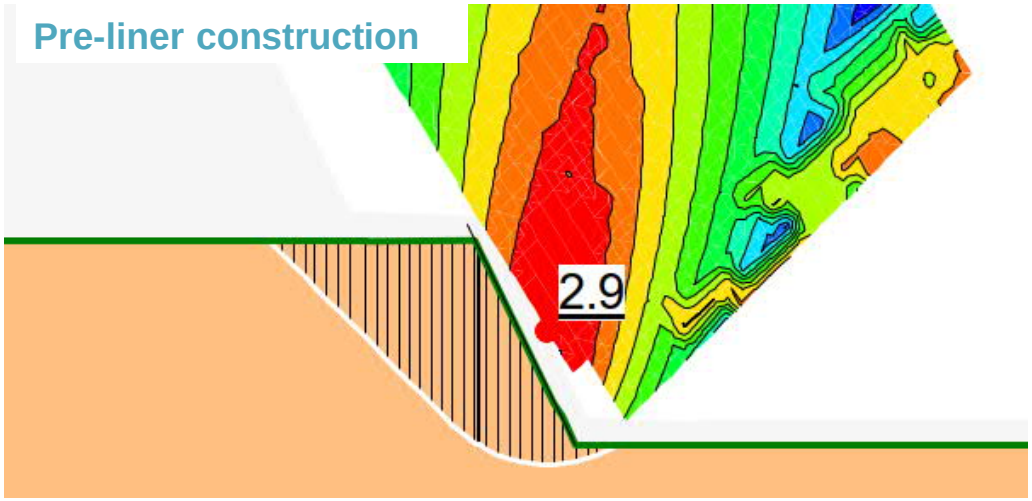
Progressive & Staged Liner Installation Constraints

- Management of exposed liner maintenance
- Logistics of simultaneous construction and filling
- Regulatory approvals
- Stormwater and leachate management
- Safety

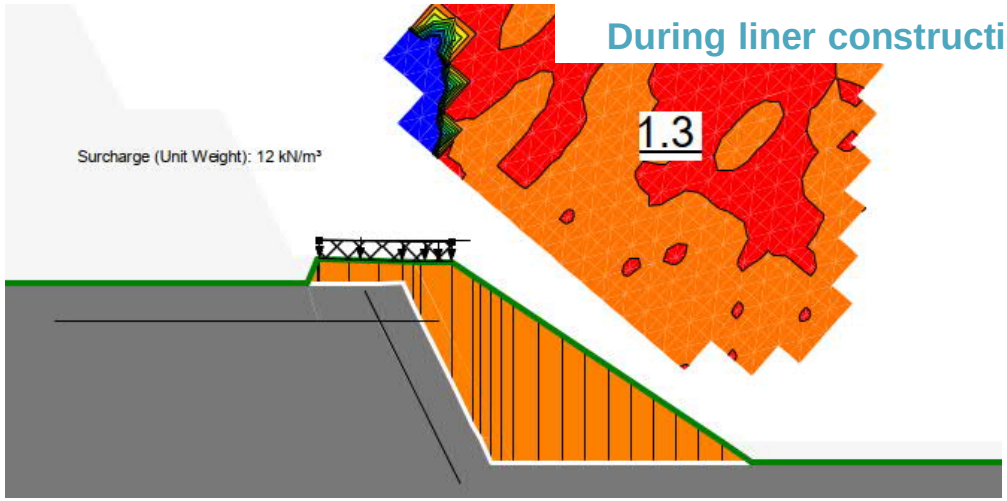
Tonkin+Taylor

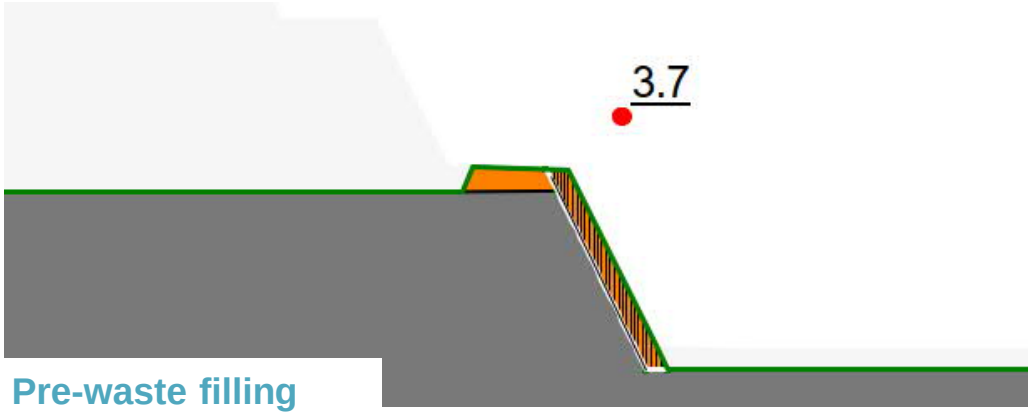
Slope stability

Pre-liner construction

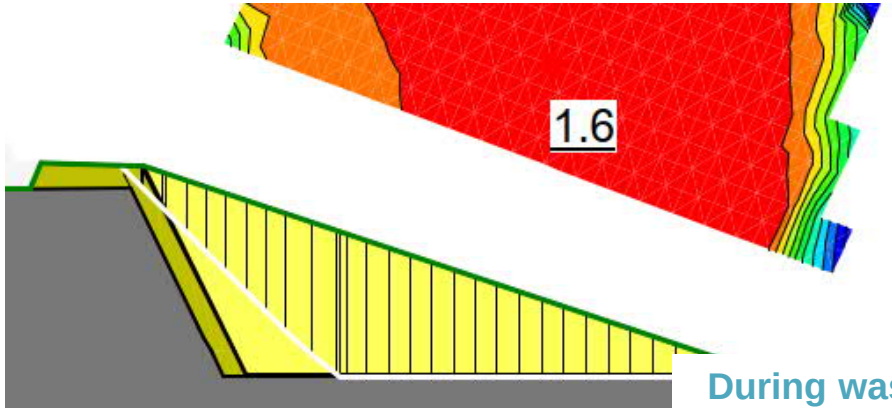


During liner construction





Pre-waste filling



During waste filling

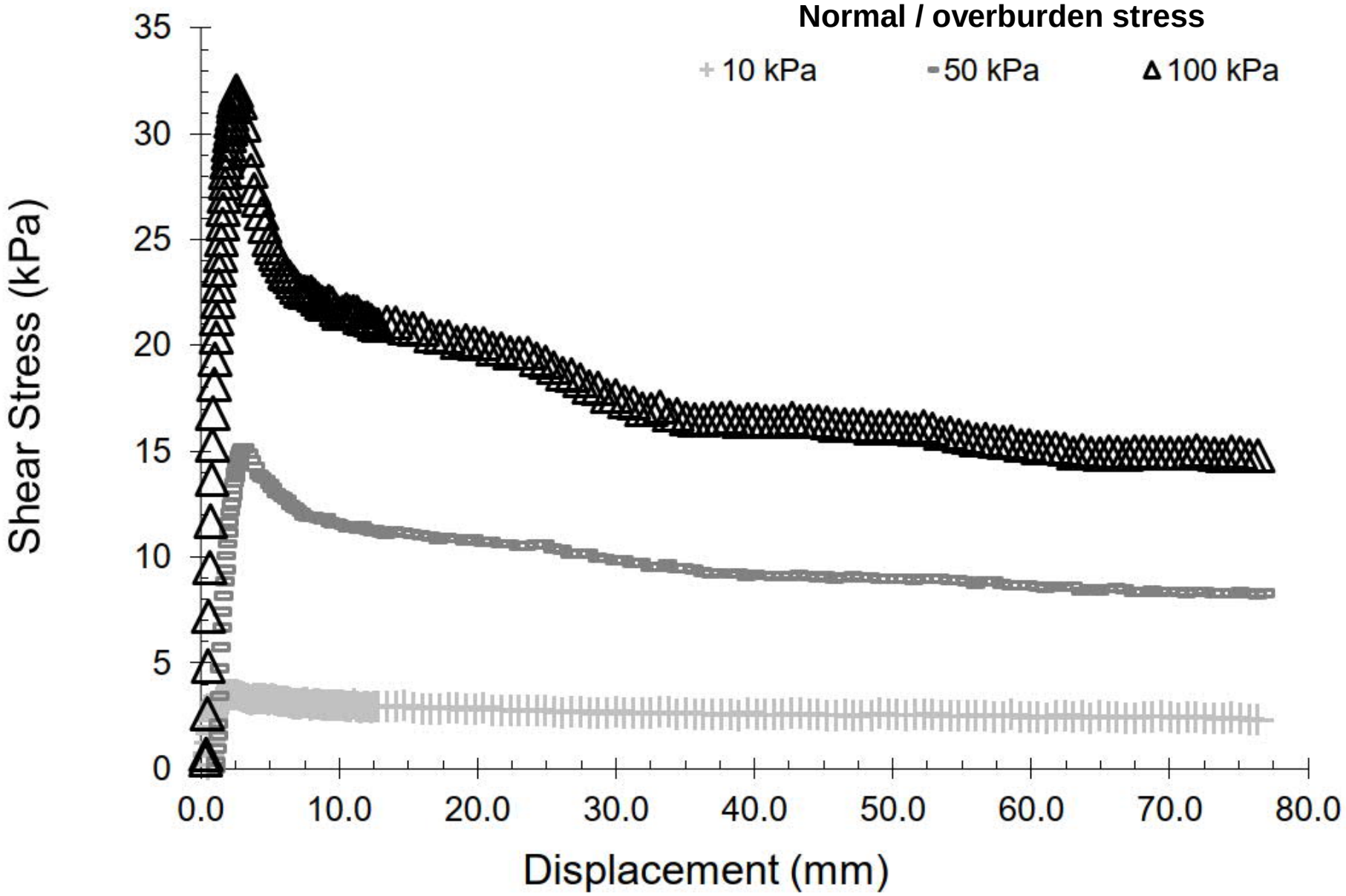
Interface Friction

Each pair of materials have different interface properties

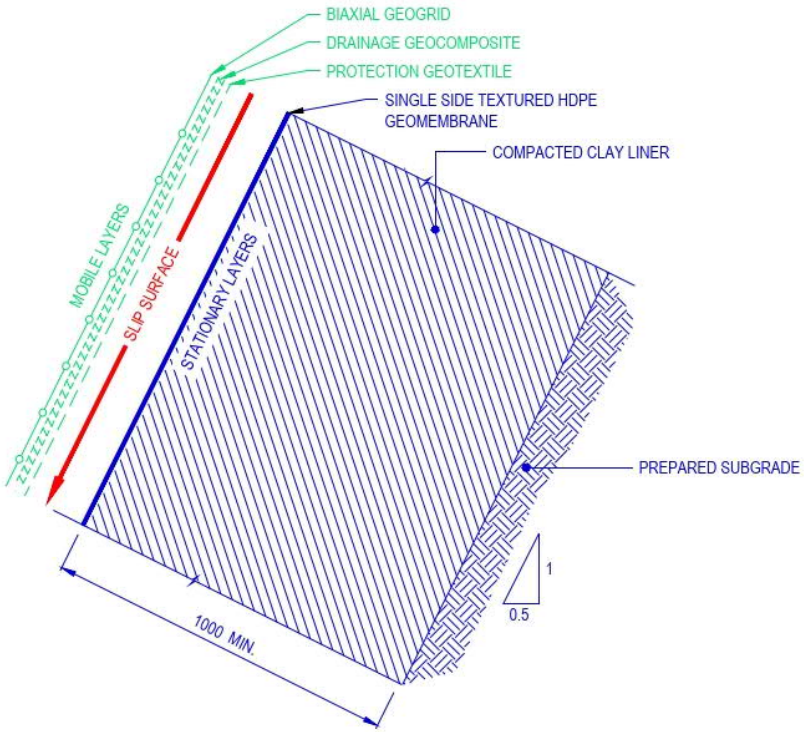
Overburden pressure influences

Interface friction can change with time and other environmental factors (hydrating GCL's for instance).

Interface friction
Shear box testing



To resist down-drag or accept it?



Waste settlement up to 25% of depth

Deep landfills → high liner settlement stresses

Stresses can be managed with either:

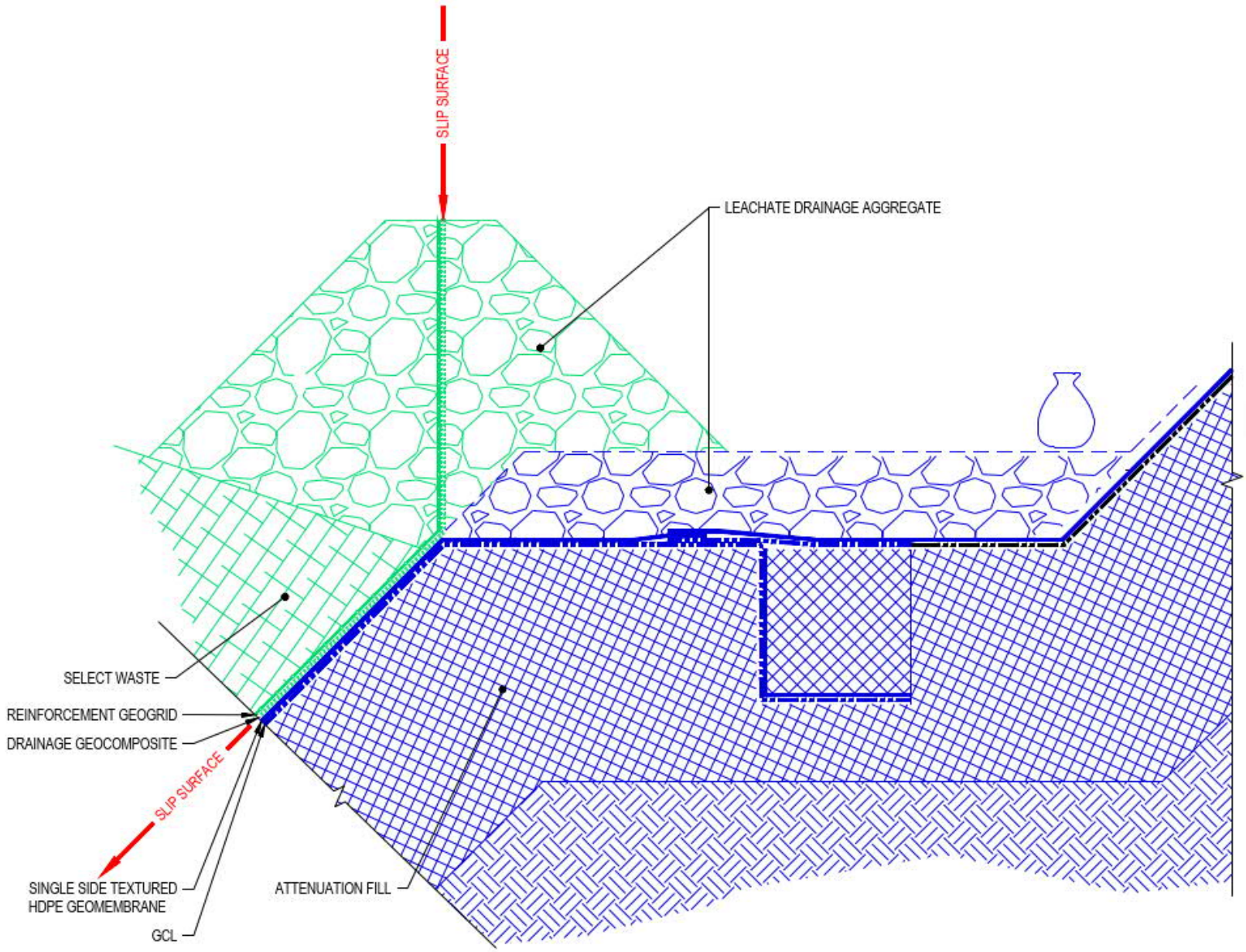
- High strength geogrids and large anchor trenches
- Mobile geosynthetic layers to prevent stress build up in underlying barrier layers

Mobile geosynthetic layers introduce a low shear strength layer into barrier system

Mobile layer must be allowed to move, with additional run out

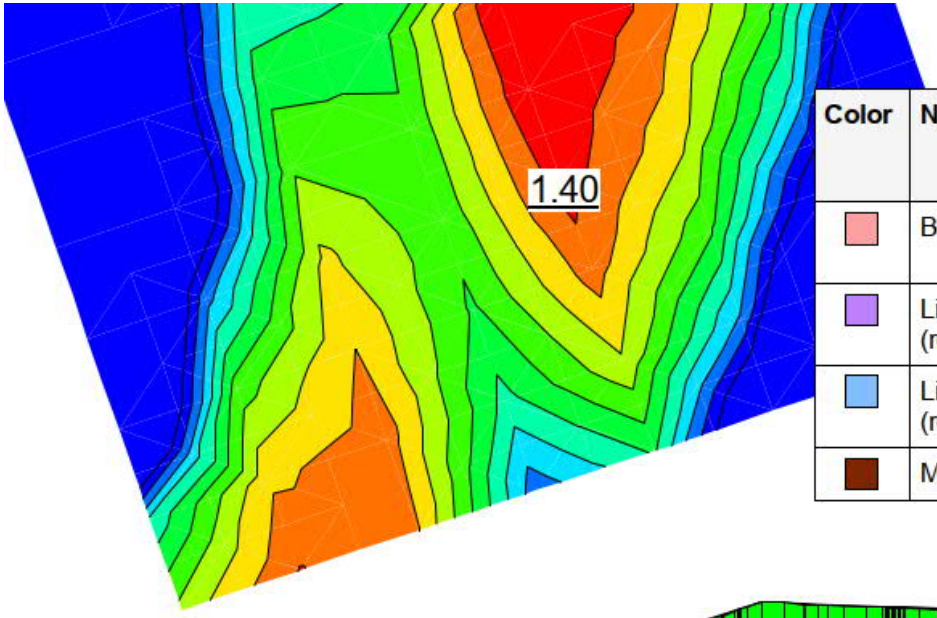
Tonkin+Taylor

To resist down-drag or accept it?



Tonkin+Taylor

Waste mass stability



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (kPa)	Phi' (°)	Phi-B (°)
	Bedrock	Bedrock (Impenetrable)							
	Liner base (residual)	Mohr-Coulomb	14	0				9	0
	Liner wall (residual)	Mohr-Coulomb	14	2				12.9	0
	MSW	Bilinear	14	6	35	30	200		0

Tonkin+Taylor

Steep Wall Geosynthetics Restraint

HIGH STRENGTH VS LOW STRENGTH.

SPACE CONSTRAINTS.

WATERTIGHT OR JUST FOR STRENGTH

RUNOUT / ANCHOR TRENCH / BOLT/BATTEN / T-LOCKS

PERMANENT OR TEMPORARY

NEED FOR ONGOING INSPECTION OR BURIED FOR LIFE

Protection of the liner

Prevention of puncture (ASTM D5514) on side walls.

Waste mass influence on side wall behaviour

Protection of materials at limit of work for future liner extension

Material strengths and weaknesses.

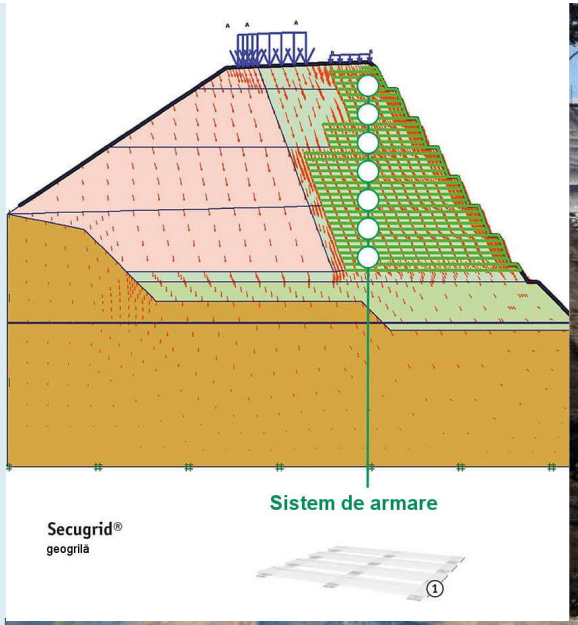
Tonkin+Taylor

Above or Below

Above ground bunds and berms

Below ground walls

Combinations of both



Conclusion

Advantages and challenges to steep wall liner design

Customised to the site and risk profile

In depth understanding of material science and the stresses/strains that materials will be subject to.

High level of knowledge of ground condition and geotechnical stability.

Careful consideration of construction practicality.

Tonkin+Taylor

Tonkin+Taylor

Presenter Information

Luke Adams

Associate Environmental Engineer

ladams@tonkintaylor.com.au

+613 9863 8686

+61490 563 582

Callum Browning

Environmental Engineer

cbrowning@tonkintaylor.com.au

+613 8796 7903

+61434 029 653