GEOANZ #1

ADVANCES IN GEOSYNTHETICS

7–9 JUNE 2022 | BRISBANE CONVENTION & EXHIBITION CENTRE

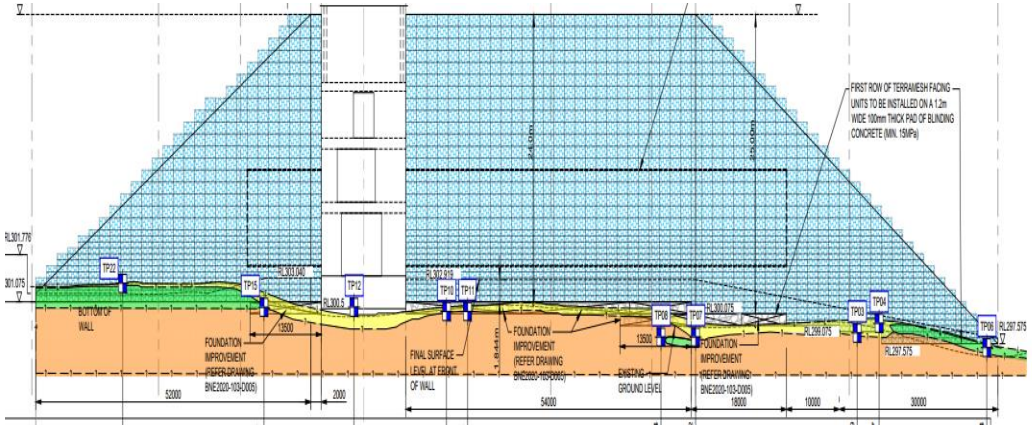
Introduction

The Ravenswood Gold Mine (QLD) Run of Mine (ROM) wall comprised a Gabion type facing with integral woven mesh tails of varying heights in combination with a high strength polyester geogrid with fibres encased in a LDPE sheath. Today we will describe the design and construction challenges faced and solved by client, consultant, supplier and construction team working together during the boundary pushing project.

The Scope of Works for the ROM wall included:

- Full design of ROM wall integrated into adjoining running stockpile and adjacent existing Rom facility onsite
- Fabrication and supply of all necessary wall components
- Additional site investigation to confirm foundation conditions prior to wall construction
- Construction support and onsite supervision
- RPEQ certification of asbuilt ROM wall

Site Area during site investigation



Refined ground model following site investigation

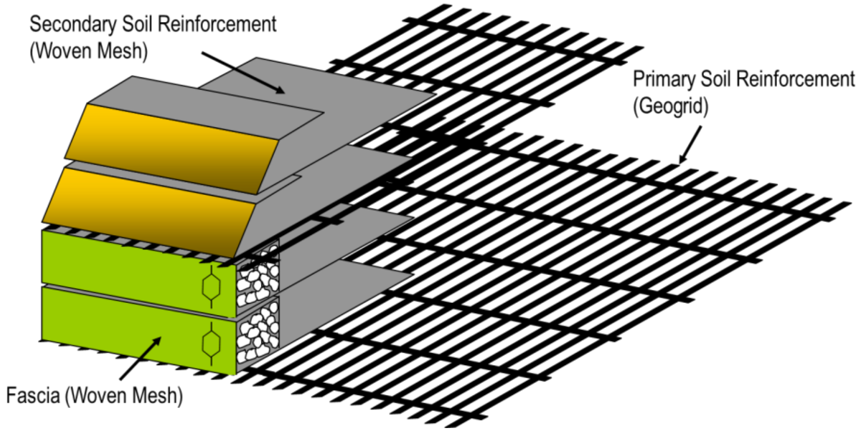
Preliminary 3D model

Reinforced Soil Wall Selection and History

Gabion faced reinforced soil structures have been in use since 1979 when a 14m high wall was installed in Sabah, Malaysia. The first integral woven mesh soil reinforced structures were installed in Australia in the mid 80's and the first composite reinforced soil structure (integral woven mesh with geogrids) was constructed in Scotland in 1997. Since then, hundreds of composite reinforced soil structures have been constructed around the world. There are numerous advantages associated with composite reinforced soil structure design:

- The use of reinforcements with different mechanical properties (i.e., strength and stiffness) allows engineers to obtain more economical designs (compared to steel only or geogrid only), as they benefit from the advantages of both materials, thus reducing the cost of reinforcement while maintaining adequate internal stability
- Double twist mesh systems are the facia & secondary reinforcement allowing for better compaction and ensuring facing stability
- The ParaMesh system uses a robust geogrid (strengths between 100kN/m and 1,600kN/m) which can be used with a variety of fills
- The geogrid terminates at the front of the structure and does not need to be wrapped around the face and it therefore unaffected by UV


VIC Roads Project - 1987

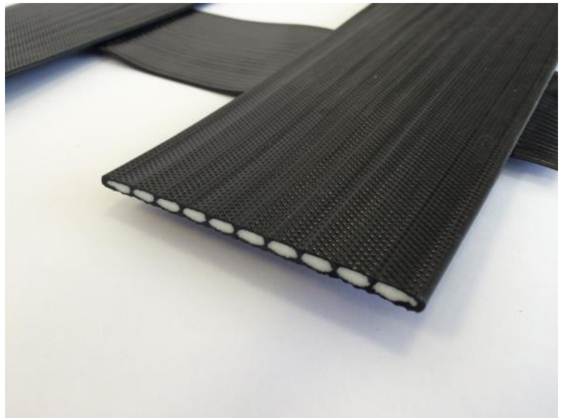



WA Mine Site - 2014

Geogrid Characteristics and Performance

The system geogrid is a planar structure consisting of a monoaxial array of composite geosynthetic strips. Each single longitudinal strip has a core of high modulus, low creep polyester yarn tendons encased in a tough, durable polyethylene sheath. The geogrid continues to perform throughout its design life in the most adverse conditions associated with waste material, mining and brownfield sites. The geogrid has several excellent performance criteria that makes it ideal for 'heavy duty 'mine crusher walls and infrastructure projects, namely;

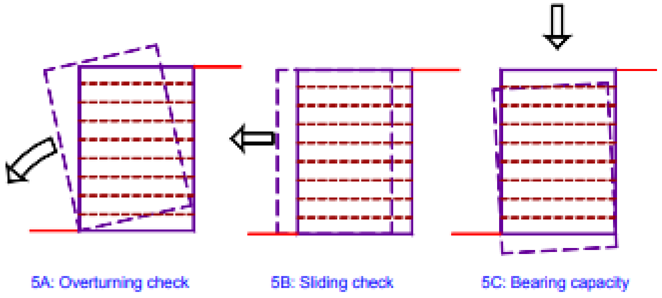
- Excellent creep behavior - over a service life of 100 to 120 years, this geogrid can sustain over 64% of its initial strength
- Durability – the polyethylene outer coating provides unmatched protection from chemical attack (the product independent BBA Certificate suggests very low partial factors for pH between 4 and 11)
- Installation damage – the outer durable polyethylene coating prevents the inner load carrying yarns from being damaged during installation (the product independent BBA Certificate suggests very low partial factors for a D_{90} particle size up to 150mm)
- Connection capacity - connection and pull-out behaviour has been tested by "Bathurst, Jarret and Associates Inc" simulating the interface between double twist mesh and this geogrid in different conditions



Reinforced Soil Wall Design - General

Tools Utilised

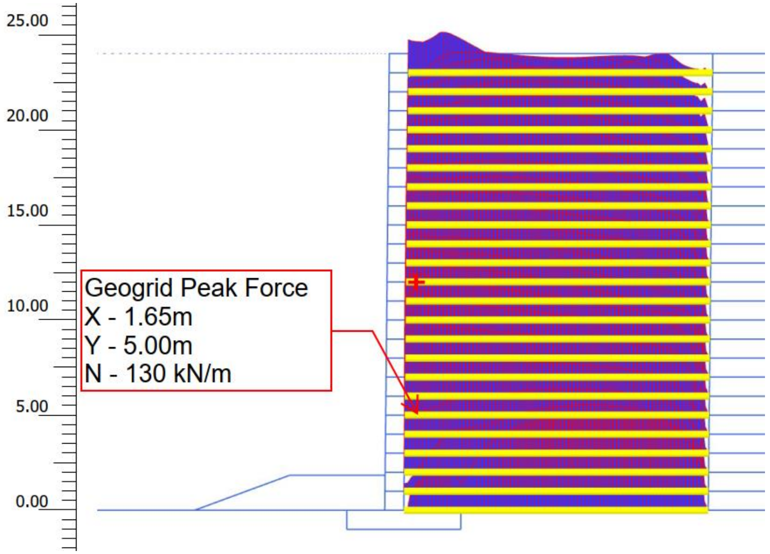
1. MacStars Stability analysis program



Analysis of:

- Sliding
- Overturning
- Bearing

2. Plaxis Finite element program

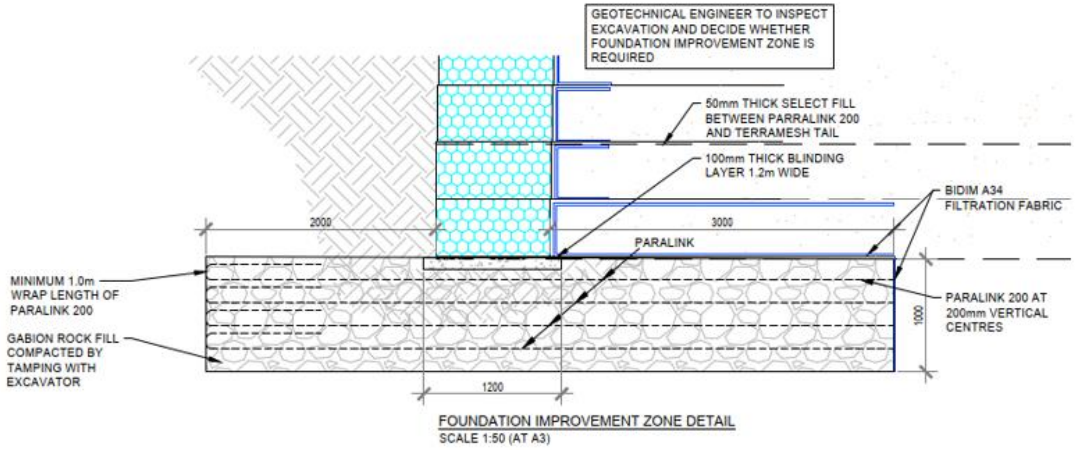


Analysis of:

- Stresses in the geogrid
- Stresses in the foundation
- Deflections

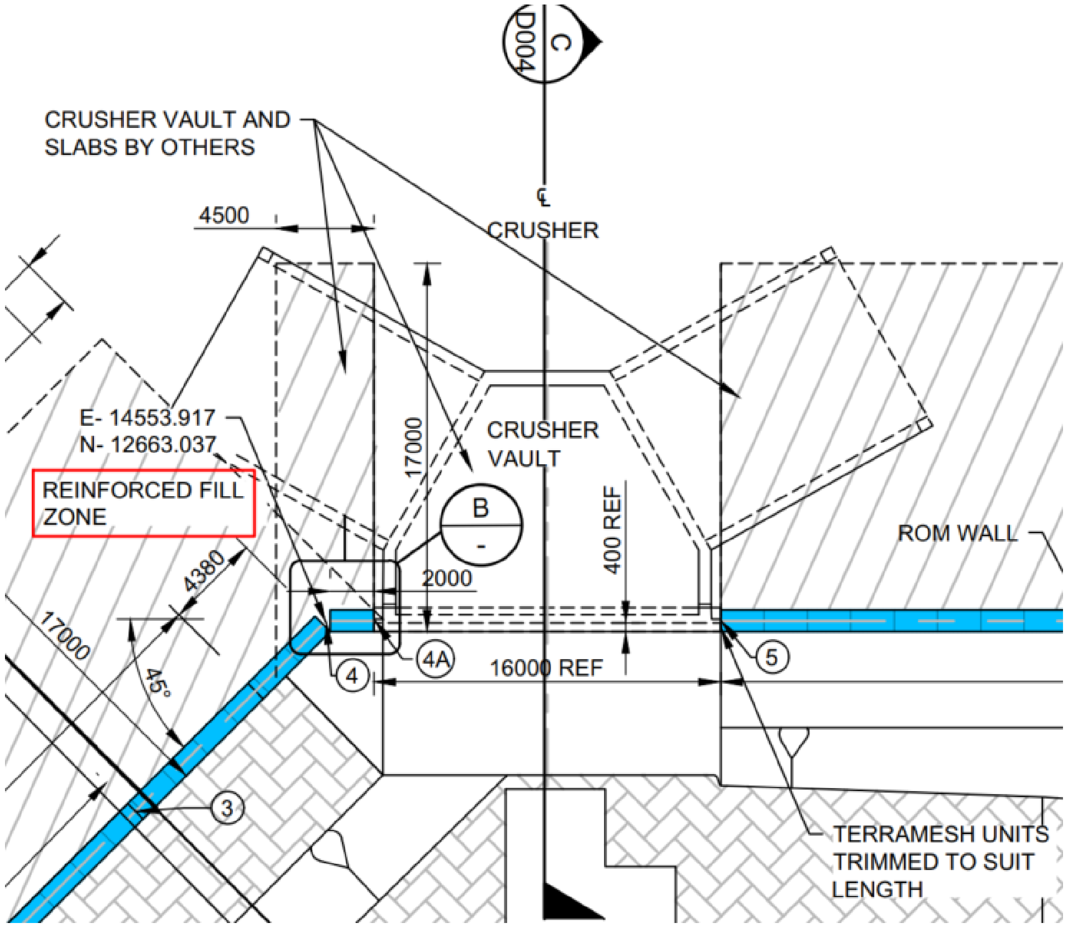
Reinforced Soil Wall Design – Ground Improvement

- Ground improvement was required as the calculated bearing pressures at the wall toe were higher than allowable
- A solution was developed which utilised the same reinforcement type as used in the wall for convenience
- Plaxis analysis indicated that bearing pressures were significantly reduced



Reinforced Soil Wall Design – Adaptability

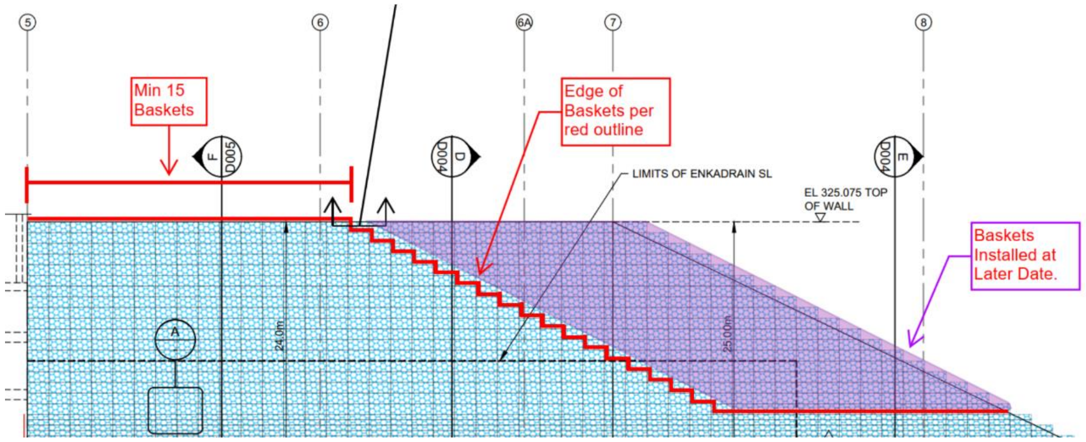
- Stepped
- Vault Interface
- Simple adjustments to wall lengths
- Use of site won materials



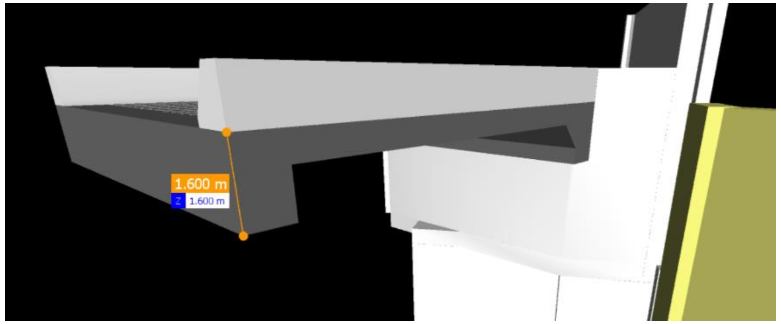
Design Amendments during Construction

Shortening of ROM Wall:
- The ROM wall was shortened in overall length.
- Details provided to allow future extension as required.

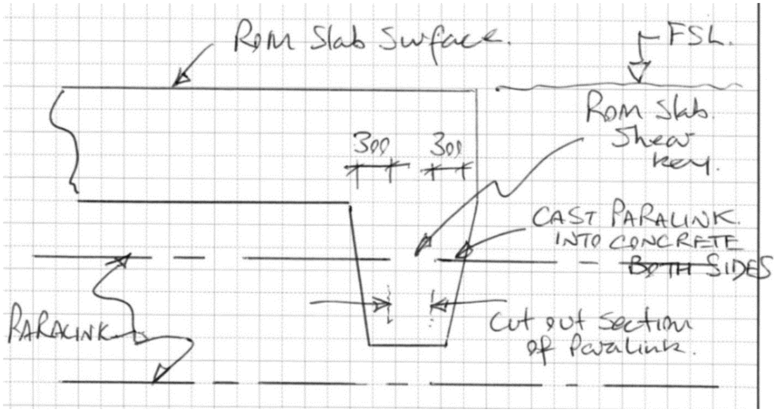
Change to Dump Slab design:
- The dump slab atop the ROM wall was completed during ROM construction, introducing a shear key.
- New shear key clashed with final layer of reinforcement.
- Detail provided to enable shear key construction without impacting on final reinforcement anchorage.



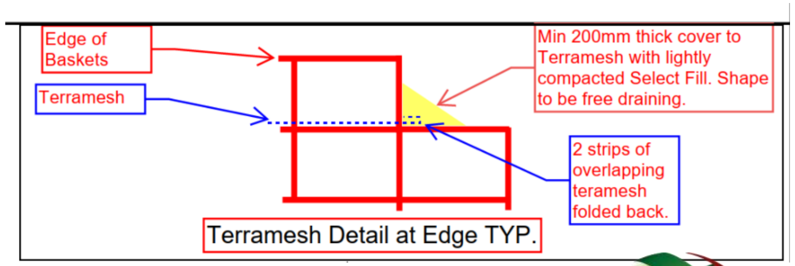
Shortened ROM wall



Model of Dump Slab with shear key



Reinforcement continuation detail



CONSTRUCTION PHASE: Translating the design intent into the finished product

- In other words, ensuring **product conformance** and **structural performance**.
- **Product conformance** was dealt with through product certification and strict adherence to MQA in local and oversees ISO manufacturing environments. Terramesh is a well proven system used over many years throughout the world in walls up to 70m high.
- Good administration of international and local freight and logistics goes without saying particularly under pressure of project delivery deadlines and awkward international health dilemmas! This project proved no exception from the outset. Deadlines were met and exceeded.
- **Structural performance** is ensured through the application of well proven, state of the art installation techniques which whilst not complicated are important to learn and encompass.
- A very old phrase originally coined by Aristotle (essentially applying to the concept of teams) has a perfect corollary w.r.t. reinforced soil retaining walls: 'The whole is greater than the sum of the parts'…there cannot be a truer statement and well worth remembering!
- It is essentially the ground crew that make this transformation happen and when you have reinforcement lengths sitting at 18m, it is hard often to comprehend the interdependence between the various components. Each activity in the process relates to the overall success.

CONSTRUCTION PHASE: Translating the design intent into the finished product

- Installation manuals are provided covering all aspects of the various processes…this however is augmented with theoretical and practical sessions conducted on site with all of the relevant components including the selected stone fill material and importantly the construction teams allocated to the various tasks. Not forgetting of course supervisors and project managers all requested to attend.
- This opportunity is taken to hone the lacing, bracing and packing techniques and identifying common errors and their rectification. Training complete; all attending walk away with the necessary information to ensure a satisfactory outcome.
- An alternative approach is to build into the project documentation the requirement for proven prior experience with the building of similar structures.


MACCAFERRI

TMS INSTALLATION MANUAL
Rev: 1, Date 12.04.2017

TERRAMESH SYSTEM
INSTALLATION MANUAL

AUTHOR: MACCAFERRI (REFERRED TO OFFICINE MACCAFERRI S.p.A.)

© COPYRIGHT MACCAFERRI

1	12/04/2017	EMEA Technical Division D. Tubertini	Corp. DT Sect. Specialist P. Di Pietro	EMEA Technical Manager M. Vicari
REV.	DATE	PREPARED BY	CHECKED BY	APPROVED BY

DESCRIPTION OF REVISIONS SINCE THE LAST VERSION
ETA Certification; Construction site management; Inclined foundation pad; Placement of structural fill; Gabion repair; Installation productivity

The information contained in this Manual is subject to change by **MACCAFERRI** without prior notice

Page 1

CONSTRUCTION PHASE: Translating the design intent into the finished product

- A quality control inspection test plan (ITP) is essential to ensure the compliance required.
- The ITP must cover general items such as setting out, tolerances, training and the acceptance of a sample unit and then progress to product conformance including delivery and storage requirements.
- Finally each section of the works should be detailed with compliance checks for each stage as well as the preparation and updating of a CQA Lot plan.
- Each of these elements are designed to ensure a smooth uninterrupted flow of construction activities with the relevant checks and balances.

QUALITY CONTROL INSPECTION TEST PLAN:

Wall section: Wing wall South:......... Main wall:......... Wing wall North:.........	Date:
Elevation: Gabion row number:	Engineer:
Weather:	Contractors rep:

Item No	Description	Who	Action Yes/No	Initials	Date
A	GENERAL				
1	**Training and sample unit acceptance** • Installation training for Contractor and Ausenco. • Sample constructed and approved for lacing, filling, bracing, geotextile installation and overall finish. • Material parameters for reinforced fill, retained fill and foundation material approved (Refer Ty • Gabion rockfill approved (Refer Genera	- - - -	- - - -	- - - -	- - - -
2	**Setting out** • Survey complete and checked.				
3	**Foundation preparation** • Excavation to line & level (Refer Found. • Founding level on very stiff or very den:				

B	PRODUCTS				
4	**Materials** • Terramesh units (TM) approved. • Gabions approved. • Bidim A34 separation geotextile (A34) approved. • Megaflo, Trinet approved if required. • Paralink 200 Geogrid (PL200) approved.	- - - - -	- - - - -	- - - - -	- - - - -
C	CONSTRUCTION				
5	**Main wall construction** • Wall alignment correctly set out • PL200 laid to correct length and orientation with no kinks or undulations (Refer Geogrid and Geotextile reinforcement notes D001). • TM units installed to line and level (Refer Gabion Terramesh notes D001). • Check junction unit splice lacing. • TM unit tails secured edge to edge at 500mm c/c. • TM facing formwork securely in place. • Braces installed correctly. • Severed/severely damaged DT mesh and / or PL200. • Damaged sections replaced. • TM units packed correctly with specified rock size and strength. • Install A34 separation geotextile. • Damage to geotextile. • Geotextile replaced?	- - - - - - - - - - - - -	- - - - - - - - - - - - -	- - - - - - - - - - - - -	- - - - - - - - - - - - -

Construction Challenges

Quality of Work

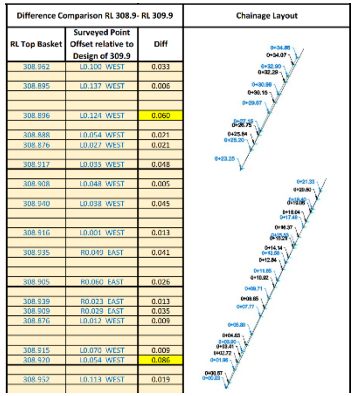
- Hand packing of baskets – lack of experience for this type of work initially thought basket fill with excavator
- Placement of basket to survey tolerance – lack of onsite survey
- Reinforcement placement and onsite care – geogrid being left exposed to UV for multiple days

General Design Understanding

- Lack of onsite site engineers with civil background
- Lack of ITP and Hold Point understanding

General misunderstanding of roles and responsibilities from onsite crew and experienced leading hands/site supervisors

Contractor and site personnel retention over construction life



Difference Comparison RL 308.9- RL 309.9			Chainage Layout
RL Top Basket	Surveyed Point Offset relative to Design of 309.9	Diff	
308.962	L0.100 WEST	0.033	
308.895	L0.137 WEST	0.006	
308.896	L0.124 WEST	0.060	
308.888	L0.054 WEST	0.021	
308.876	L0.027 WEST	0.021	
308.917	L0.035 WEST	0.048	
308.908	L0.048 WEST	0.005	
308.940	L0.038 WEST	0.045	
308.916	L0.001 WEST	0.013	
308.935	R0.049 EAST	0.041	
308.905	R0.060 EAST	0.026	
308.939	R0.023 EAST	0.013	
308.909	R0.029 EAST	0.035	
308.876	L0.012 WEST	0.009	
308.915	L0.070 WEST	0.009	
308.920	L0.054 WEST	0.086	
308.952	L0.113 WEST	0.019	

Asbuilt survey report

Exposed reinforcement

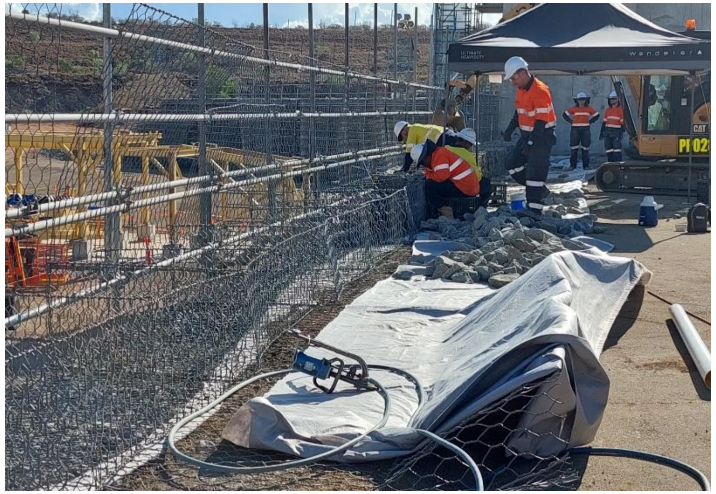
Out of tolerance baskets

Progress Photos

Subgrade Preparation – excavation for ground improvement treatment

First 1m of ROM wall following Ground Improvement and blinding

Approximately RL303



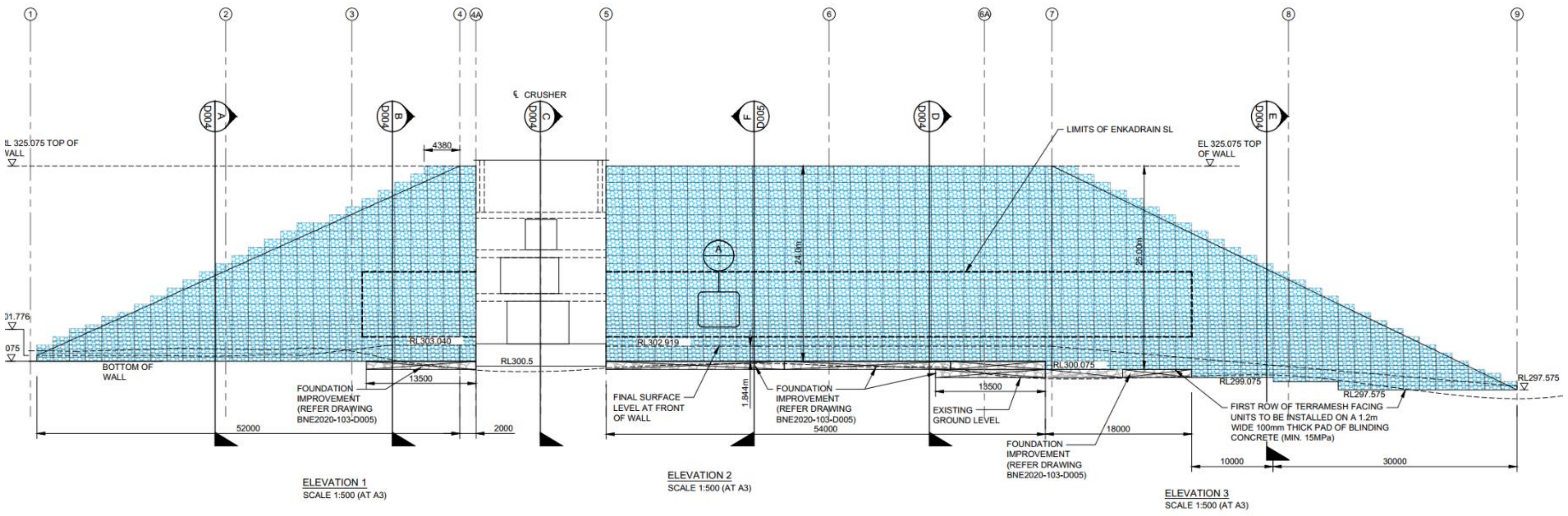
Basket fill stacking prior to framing use

Peak Construction Productivity

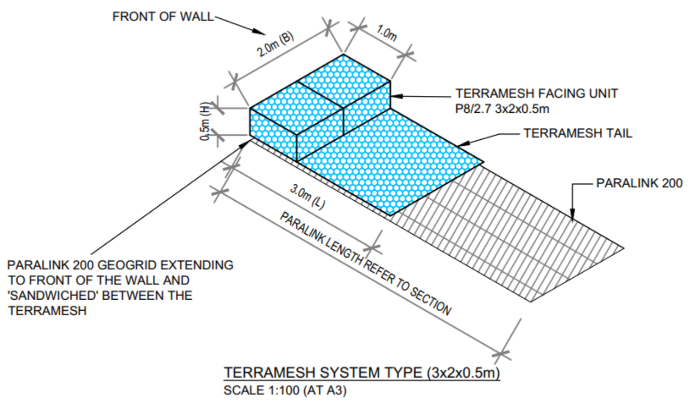
At peak construction the contractor was installing 20 units a day and approximately 340m3 of select fill placement.

- ➢ The contractor had two separate crews for day and night shift:
  - ➢ Day shift undertaking the select fill placement and compaction.
  - ➢ Night shift undertaking, reinforcement placement, and basket installation including stacking.

- ➢ At this peak productivity framing for the baskets was in use.



IFC elevation Drawing

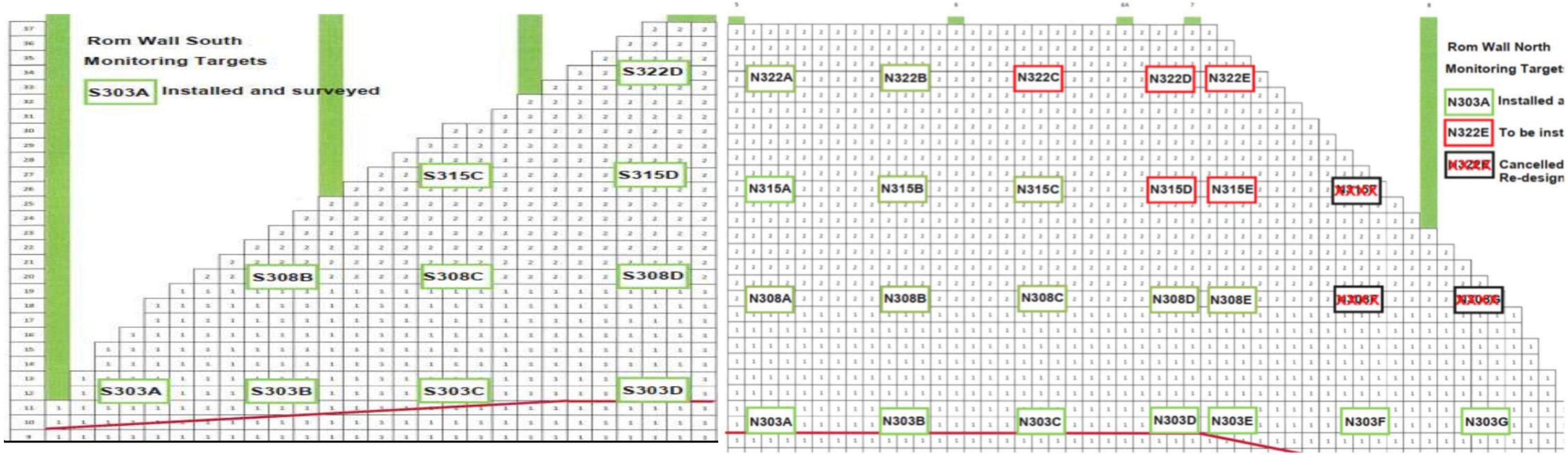


Unit – 2m (B) by 0.5m (H)

Movement Monitoring

During the construction monitoring was undertaken by the Client typically every third week.

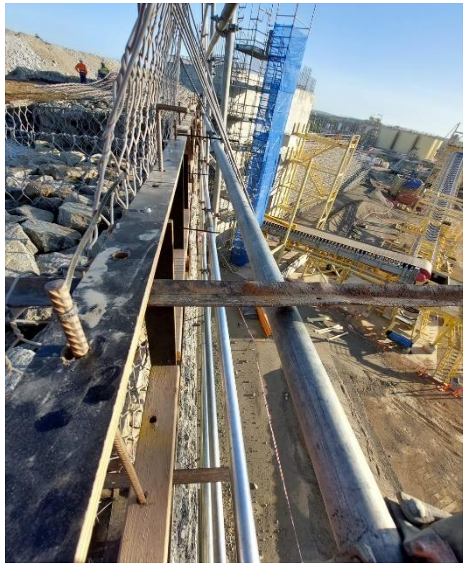
- Settlement measured exceeded modelled anticipated settlement.
  - With bottom survey points matching with anticipated settlements
  - Internal settlement exceeding anticipated
- Survey Points white sprayed rock within basket due to usual survey target not available onsite



Progress Photos

Approximately RL308

Approximately RL315



References

- Vicari M. 10 Years of experience with reinforced soil structures using steel wire mesh and geogrids