

Appendix D Bund Calculations

MACCAFERRI

Green Terramesh Rockfall Protection Bund Technical Proposal



A typical rockfill face GTM bund

| | |
|---------------------|---|
| Project: | Redcliff School Rockfall Protection Bund |
| Client: | MWH New Zealand Ltd |
| Reference: | CA3020_R2 |
| Date: | 21-05-2013 |
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1) Introduction

Maccaferri NZ Ltd has been contacted by MWH New Zealand Ltd with a view to preparing a REVISED design suggestion considered for using Green Terramesh reinforced soil bund as a long term permanent solution to potential rockfall hazards at Redcliff School, Christchurch.

This revision involved additional check for a boulder bounce height of 1.6m.

Maccaferri NZ proposal is based on the information provided in the following documents.

- Email dated 1/5/2013

Where the data is incomplete we have had to assume input values, which have not been independently verified and which may contain assumptions and inaccuracies regarding geotechnical, hydraulic or other relevant parameters. We refer you to our appended disclaimer relating to this proposal which outlines the extent of our services in support of your project.

The following calculations pertaining to the design suggestion are valid only for the structure and materials contained in the specification described herein for the geometry, loads, soils and other input parameters, design life and other relevant factors required for this project. Any changes to these parameters or substitution of other material properties will result in a change of the safety factors and/or serviceability of the structure and will require re-design.

The areas under study have been, and continue to be, profoundly affected by the series of earthquakes that started with a quake (Richter magnitude of 7.1) on the 4th September 2010. During earthquakes rocks detach from mid-slope and upper slope outcrops (often as a result of seismic shaking that induces accelerations) and these roll and bounce down the slopes posing a significant threat to the infrastructure and public below.

2) Summary of Maccaferri Rockfall Protection Solutions

The Maccaferri MacRO systems range of products includes primarily rockfall protection products, and secondarily catastrophic natural hazard mitigation solutions including:

- **High strength mesh systems** (with strengths up to 300kN/m)
- **Dynamic rockfall barriers** (ETAG27 certified at energies from 500kJ to 5000kJ)
- **Green Terramesh (GTM) rockfall protection bund** (reinforced soil systems)
- **Hybrid fence or “Attenuator” systems**

Depending on site specific conditions, impact characteristics and economic factors, it is considered likely that the client would use a combination of these products on a site by site basis.

Green Terramesh reinforced soil rockfall bund has been identified as the permanent solution providing the least maintenance issue yet having extremely high energy absorption from rock impact. This proposal is thus focusing on derivation of the necessary embankment geometry for its intended use.

3) Available input Data and assumptions

Provisional data provided by the client was collated and interpreted to produce computer and mathematic calculations.

The input data provided for the GTM Bund geometry from trajectory analysis:

| Parameter | Value |
|---|----------------------|
| Boulder unit weight | 25 kN/m ³ |
| Nominal boulder (diameter) | 2.20 m |
| Bounce height at the proposed embankment location, h_b (bottom) | 0.5m |
| Bounce height at the centre of the block, h_d (Centre of mass) | 1.6m |
| Velocity at impact | 9.0m/s |
| Expected kinetic energy | 557kJ |

The soil parameters used in the analysis of internal stability for the GTM embankment are listed below. Maccaferri assumes no responsibility for their accuracy or results due to their inaccuracy.

| Soil property | Embankment Fill | Foundation |
|---|------------------|------------------|
| Soil description | In-situ material | In-situ material |
| Angle of internal friction, ϕ'_{des} (Deg) | 30 | 30 |
| Bulk unit weight of soil, γ (kN/m ³) | 19 | 19 |
| Cohesion, c(kPa) | 0 | 0 |

The following factors of safety are referenced from international guidelines such as FHWA :

| Description | Factors of Safety | |
|--------------------|--------------------|---------------------|
| | <i>Static Case</i> | <i>Seismic Case</i> |
| Internal Stability | >1.5 | >1.1 |
| Global Stability* | >1.5 | >1.1 |

Note: Global stability is not likely to be an issue as the GTM bund is founding on a levelled/flat ground.

Seismic stability:

The considerations for earthquake effects on the integrity of the Green Terramesh embankment are as follows:

Design peak ground acceleration (PGA) = 0.35g (assumes 1/500 AEP earthquake with M7.5)

This ground acceleration is applied to the internal stability analysis of the structure without any further reduction factors.

Should our assumption regarding criticality of the structure be incorrect then further analysis to include seismic loads will be required.