

Use of geotextiles to overcome challenging conditions at the seawall project in Port of Brisbane

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ABSTRACT: Stage 1 of the Future Port Expansion (FPE) Project located at the Port of Brisbane, Fisherman Islands involved the design and construction of a 4.6 km long seawall. The Seawall up to 8 m high, was constructed in waters up to 6 m deep and extends 1.8 km into Moreton Bay from shore. The factors which significantly impacted its design and construction, included the weak and deep soft clay subsoil profile, potential issues related to settlement, instability and loss of materials due to seabed penetration, marine conditions, and environmental concerns due to the proximity of the sensitive Moreton Bay Marine Park. High strength geotextiles up to 850 kN/m were used to overcome stability issues related to weak marine clay at the seabed and a filtration geotextile was used to protect the sand pancake below the rock bund. Damage trials were conducted on the selected geotextiles to assess the potential for damage from rock placement and trafficking.

1 INTRODUCTION

The Port of Brisbane is located at the mouth of the Brisbane River at Fisherman Islands in Brisbane. The Port land has seen rapid development due to increased Port activities and this growth is expected to continue for the next 25 years and beyond. The Future Port Expansion (FPE) Project will provide the land to cater for the increased demand in the future.

The ultimate objective of the FPE Project is to allow the Port to reclaim and develop an additional 230 ha of port land including extending the current quayline by a further 1800 m. The reclamation will be carried out using channel maintenance dredging materials. The first stage of this process was the construction of a 4.6 km long and up to 8 m high seawall to encompass the area so that reclamation could be carried out in an environmentally friendly and controlled manner.

The client used an Alliance delivery mechanism to deliver Stage 1 of the project because of the significant geotechnical, environmental and construction risks and constraints associated with the project. These included, highly variable soft clays extending over 30 m below the seabed on the eastern wall alignment, the close proximity of the Moreton

Bay Marine Park, varying water depths, wind and expected sea conditions during construction.

Preliminary designs indicated the consistency of the marine clay at seabed level to be generally too weak to support high embankments unless the ground was improved or the construction staged allowing the clay to gain some strength. Most options were not feasible due to uncertainties on the effectiveness of the method, time constraints and/or associated costs. The use of a high strength geotextile was ultimately assessed to be the most cost effective and least risk solution.

A rock embankment placed on a high strength geotextile laid on the seabed was the design adopted where the seabed is shallow (1 m below low water). However in the deeper areas (3.5 m below low water), a wide sand pancake was included in the design because of weaker subsoil conditions (see design section for East Bund in Figure 1). The rock bund forming the upper part of the seawall was then placed on this sand pancake. During construction an appropriate filtration geotextile was selected to cover and contain the sand to prevent losses from the effects of tides and waves. Damage trials were conducted on the selected geotextiles to assess whether significant damage would occur during the placement of the

rock and construction trafficking above and what allowance should be made for these effects.

2 SITE CONDITIONS

Based on the published geology map of Brisbane (1:100,000 scale), the site is underlain by Quaternary marine deposits consisting of “fluvial lithofeldspathic sublittoral sand and muddy sand”.

The main geological formations across the project site can be summarized as Holocene deposits overlying Pleistocene deposits, which in turn overlie the Petrie Formation, which consists of basalt bedrock. The Holocene alluvial deposit consists of two sub-layers with the upper layer generally between 0 to 4 m thick, comprising mainly sands with interlayered soft clays and silts. The lower layer comprises very soft to firm compressible clay generally normally consolidated from about 3 m depth below the seabed.

Along the East Bund, the soft clay at shallow depth is weak, having undrained shear strength values of 3 to 5 kPa, increasing towards the shoreline. The thickness of the layer varies from about 8 m to 30 m along the alignment.

3 GEOTEXTILE DAMAGE TRIALS

At the initial stages of the design, risk assessments were carried out. Damage to high strength geotextiles during rock placement and trafficking was identified as a significant hazard. However, it was recognized that downrating the basal geotextile strength, was an acceptable way to treat such issues in the design. Theoretical formulae were available to assess the requirements of a geotextile but not to assess the damage factors. There were also no documented experiences on damage due to trafficking on rock placed on a geotextile. Also of great concern was the potential for damage of the filtration fabric, because of the potential consequences if sand was sucked out by the tides leading to collapse of the rockwall above and consequent major failures.

From the outset it was decided to carry out a set of field trials to assess these effects using typical rockcore and armour materials to be used on the project.

3.1 Basal high strength geotextile

Although trials were conducted on several products only the trials conducted on the materials of the successful tenderer are discussed in this paper. The geotextiles tested were Maccaferri Rock WX200 (200 kN/m) & WX800 (800 kN/m) manufactured by Polyfelt Asia and supplied via Maccaferri Brisbane.

The trials were conducted in one of the reclamation paddocks filled with dredged mud capped off with a

2 m thick sand base. Dynamic Cone Penetrometer testing conducted to assess the strength variation of the base generally indicated medium dense conditions.

The geotextile was supplied 4 m wide, which was stitched together to form a panel of about 12 m × 12 m. Two types of seams (J – Seam and a Butterfly Seam) were used to make an additional check on the effects on seams.

To hold the geotextile in place immediately after placement, smaller rock was placed as a weight along the edges of the test panel. Another issue of concern was the effect of larger rock falling on ballast rock placed to keep the geofabric in place on the seafloor. To simulate this and assess possible damage, a row of smaller rock was placed along the centreline parallel to the warp direction.

The panel was divided into 4 equal cells so that the seams were running along the centerlines of the cells. The trials were conducted using maximum 300 mm rock core with varying the number of drops and/or drop height. The two drop heights employed were 1.5 m and 3.0 m. The latter was used only as an assessment of the worst case scenario as generally the drop height employed during actual construction was always less than 1.5 m. Even the 1.5 m drop is somewhat conservative because in the Project part of the drop would be cushioned by water buoyancy.

On completion, rock core was carefully removed from the geofabric by hand after the bulk was removed by excavator bucket to assess, measure and photograph the damage prior to quantifying the damage. To assess the effect of construction vehicle movement, the removed rockcore was placed over the geofabric to form an access track wide enough for a 45 T excavator to travel. The length of the access track was about 5 m and the height was 1.0 m. This track was then subjected to 16 passes of the excavator moving parallel to the west direction. The number of passes used was excessive compared to actual conditions during construction.

For the basal geotextile, the damage was calculated as a ratio of the width of damaged section over the total width of the panel or cell. Random parallel lines were drawn and the assessment for each line was assessed and only the worst case is summarized in Table 1.

The results indicated that:

- Except for an outlier, the damage factor varied between 1.2 and 1.8.
- WX800 showed better resistance than WX200.
- Tracking damage is more significant than damage created by rockcore drops.
- WX200 was significantly damaged by the tracking trial.

Based on the test results it was decided as a minimum to use geotextiles whose strength is at least double the 200 kN/m strength. A constant damage

Table 1. Summary of damage factors (Basal Geotextile).

Test Locn.	Drop	Factor worst case	Remarks
M200/1	2 × 1500	1.7	J Seam
M200/2	1500	2.4	J Seam
M200/3	1500	1.4	Test over ballast
M200/4	1500	1.6	B Seam
M200/5	3000	1.8	B Seam
M200	Tracking	60–70% of test section damaged	
M800/1	1500	1.3	
M800/2	1500	1.2	Test over ballast
M800/3	1500	1.2	B Seam
M800/4	1500	1.4	B Seam
M800/5	3000	1.5	J Seam
M800	Tracking	1.8	

factor of 1.7 was used for all grades of geotextile between 400 kN/m and 850 kN/m used on the project.

3.2 Filtration geotextile

The client was very concerned about the effects of rock placement and trafficking on the filtration geotextile covering the cohesionless white sand. Therefore the damage trials carried out on the filtration geotextile were more extensive. The geotextile trialed was a 1200 g/m² nonwoven staple fibre material (Terrafix 1200R) supplied by Soil Filters Australia.

As the filtration geotextile is placed over a sand pancake at and below the low tide level and the rock was to be placed and not dropped, only trafficking trials were conducted. The geotextile was anchored to an area of moist, loose to medium dense white sand in a reclamation paddock and 0.3 t armour rock placed (by excavator) over the geotextile to varying heights. The rock surface was divided into 4 sections, each approximately 4 m square, so that several trials could be conducted.

The results of a series of trials conducted with a 30 T excavator are summarized in Table 2.

Table 2. Summary of damage factors of trials T1 to T7.

No.	Material cover and no. of passes	No. of fabric punctures
T1	0.3 m of fine sand – 6 passes	Nil
T2	no cover - 6 plus 1 slight screw of tracks	Nil
T3	1.0 m of fine core – 12 passes	1 *100 mm tear [#]
T4	0.35 m of 60/40 mm crushed aggregate – 6 passes	Nil
T5	1.2 m of 0.35 t armour rock over 0.3 m of fine sand – 12 passes	Nil
T6	0.9/1.0 m of 0.35 t armour rock – 12 passes	1*75 mm tear [#] and 6 tears (20–30 mm)
T7	0.3 m crushed concrete 75 mm passes	Nil

(# Damage assessed to be by bucket on uncovering test panel)

There were numerous indentations which were also recorded but not included in the above table. The presence of indentations indicated the significantly high strain the geotextile could withstand without rupture.

Further trials T8 to T10 were conducted with a 45 T excavator using previously tracked panels (T8 & T10) and a new panel (T9). The results summarized in Table 3 indicate that the damage from the 45 T excavator was greater than that from the 30 T. Also the damage on re-used geotextile was greater.

Table 3. Summary of damage factors of trials T8 to T10.

Trial No.	Material description	No. of passes	No. of fabric punctures (tear width)
T8	1.1 m of armour rock	12 plus 3 track screws	3 (50-75 mm)
T9	1.0 m of core rock	12 plus 3 track screws	6 (10-50 mm)
T10	1.1 m of armour rock	12 plus 3 track screws	12 (10-150 mm)

For trials T11 to T13, 1.0 m of core rock (T11) and 1.0 m of armour rock (T12 & T13) were placed over new fabric and subjected to 12 passes of a 30 T excavator plus 4 track screws on T11 and 6 on T12 and T13. No punctures were observed in T11 and only two tears, maximum 25 and 75 mm, were observed on each T12 and T13 panels respectively.

Subsequent to Trial T11, approximately 0.3 m thick layer of core rock was placed on the previously trafficked geotextile and was subjected to the following at the same location:

- Full downward pressure of excavator bucket
- Four free thumps of the bucket
- Bucket screwing causing all rock to move.

The above actions produced only two (2) small (30 mm) punctures indicating the robust nature of the geotextile used.

4 GEOTEXTILE PLACEMENT FROM THE BARGE

On the Project, a ‘multipurpose’ barge was used for laying both geotextiles and for placing the sand through a spreader system. A flat-top barge, 53 m × 17 m, was modified for the Project (see Figure 2). The unloaded barge has a draft of 0.6 m.

In general the barge consisted of 3 zones:

- The high strength geotextile deployment zone on the port side of the barge.
- The ballast storage and loading zone on the starboard side of the barge, later used for the deployment of the filtration geotextiles.

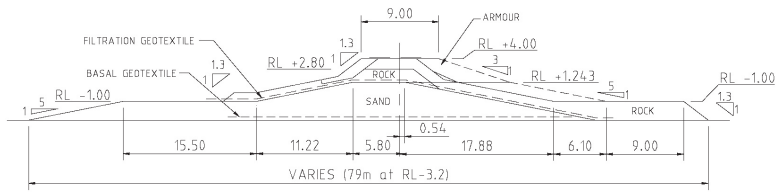


Figure 1. Typical section on east bund.

- The barge controls, facilities, power and hydraulic systems running along the centre of the barge.

A tug was used to move the barge from the load out facility to site where it assisted in setting anchors. The barge positioned and moved itself once set with the hydraulic winches. At the completion of an anchor set, the tug would assist in retrieving the anchors and returning the barge to the load out facility.

Geotextiles were stitched offsite using a J seam into panels up to 42 m wide and 100 m long. The basal geotextile was rolled over in front of the barge and under as shown in Figure 2 with the initial panel done by divers. To avoid geotextile folding transversely 12 mm reinforcement bars were attached to the geotextile with cable ties at 10 m spacing to hold the geotextile tight. Ballast was placed to hold the geotextile in place on the seabed.

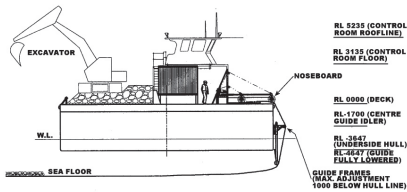


Figure 2. Placement of high strength basal geotextile.



Figure 3. Completed seawall.

The filtration geotextile was required to cover the sand and separate the sand from rock above to minimize sand losses due to wave action. The filtration geotextiles were stitched together using a pray seam stitch to panels of size 32 m x 40 m and transported to the site. The filtration geotextile panels were placed on top of the sand straight off the starboard side of the barge (the area previously used as ballast storage during the placement of the high strength geotextile) as the sand was placed from the sand spreader (attached to the starboard side of the barge). To minimize the risk of the geotextile moving, rock was placed to cover the fabric at the crest (using land-based methods) as soon as practical.

5 CONCLUDING REMARKS

Geotextile damage trials were conducted to assess the damage due to rock placement and due to construction trafficking. The damage factors calculated were successfully used in the design of the high strength geotextiles. The trials conducted to assess the damage on filtration geotextiles due to construction trafficking indicated that the damage was minimal if 1200 R geotextile was used and the excavator weight was limited to 30 T as long as a 800 mm minimum height of rock cover is used before construction traffic is allowed to traffick it.

The FPE Seawall Project Stage 1 was designed based on the results of the trials conducted and the construction was successfully completed in March 2005 (Figure 2).

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