

The Challenge of Geotextile Sand Containers as Armour Units for Coastal Protection Works in Australasia

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Abstract

Sand filled geosynthetic elements are playing an increasing role in the construction of coastal and marine structures. Traditional construction techniques utilising rock, concrete and steel are being increasingly challenged by alternatives offered in geosynthetic forms for revetments, scour protection, groynes, berms, artificial reefs, reclamation and dunal stabilisation to name but a few.

Furthermore, improved materials, design and construction methods of such structures are enhancing and diversifying the range of possibilities and applications.

This paper outlines the historical development, practical application and evaluation of geotextile armour units installed in coastal protection structures in Australasia.

1. INTRODUCTION

A significant number of structures in the Australasian region have been constructed using sand contained in geotextile forms over the last 20 years. The practical experience has resulted in an evolution of the state of the art with improved materials, design methods and construction methods. The use of sand filled geotextile forms is enhancing and diversifying the range of practical possibilities and applications such as revetments, scour protection, groynes, berms, artificial reefs, reclamation and dunal stabilisation. With the increasing number of

diverse community groups involved in the process of consultation, planning and approval, in some cases geotextile structures are providing solutions to coastal protection and improvement where traditional materials and their impacts and costs have not been acceptable to the community and approval authorities.

A range of coastal protection projects using sand filled geotextile structures have been constructed in Australia at sites from estuarine to open coast since 1985. Numerous identified sites are as listed below:

- Green Island
- Gold Coast Broadwater
- North Kirra Groyne
- Russell Heads
- Lake Victoria
- Maroochydore River and Beach
- Kinka Beach
- Great Keppel Island
- Hamilton Island
- Troubridge Island
- Airlie Island
- Towra Point
- Belongil Spit
- Stockton Beach
- Motueka N.Z
- Waihi N.Z.

Selected benchmark projects have been evaluated and show the progression to the present “state of the art”.

2. BENCHMARK PROJECTS

2.1 North Kirra Groyne

Project location: Nth Kirra, Gold Coast

Date constructed: September 1985

Principal: Gold Coast City Council

Description: 120m long x 5m high sand filled groyne

Cost: ~\$300,000

Project objectives: A temporary structure was needed to retain nourishment to restore the eroded beach, whilst long term nourishment solutions were resolved to restore the long eroded southern Gold Coast beaches. The eroded conditions of these beaches had long been associated with the economic down turn of the immediate area due to poor tourism figures.

Site conditions: Easterly facing open surf beach with an offshore max wave height of >12m.

Design Criteria: Life - 5 yrs; Wave height - max breaking wave ht = 5m

Community requirements and constraints: As the site is a popular surfing area with a local surf life saving club, the structure had to be safe for swimmers and surfers. It also needed to be removable if necessary after a permanent solution was implemented.

Construction techniques utilised to achieve objectives: The sand filled geotextile groyne was constructed of 100m long tubes encapsulated in geotextile envelopes. To minimise risk during construction, and to allow for erosion of the seabed after construction, the groyne was constructed in a de-watered excavation following initial beach nourishment. This construction technique required an all weather, around the clock program, utilising a six inch suction dredge pumping a series of one metre diameter non-woven geotextile tubes, that in turn were completely encapsulated in layered diaphragms.

Materials: A heavy duty UV stabilised non-woven needle punched geotextile (Terrafix®

1200R) was used with polyester thread in all seams.

Evaluation and comments: The project was ambitious in regards to the size of the structure and location in an active surf zone. Conventional armour units were not an acceptable option due to the cost and difficulty associated with the ultimate removal of rock or concrete. This groyne was a success in terms of achieving its primary objective of a safe temporary structure for beach stabilisation despite damage to the seaward end due to vandalism. The groyne length was reduced by about 20m before it was completely covered by a regional nourishment scheme commenced in 1990. The experience with vandalism lead to trials of coatings such as bitumen and early patching techniques. As the risk of damage is greater with tubes there has been a trend away from tubes to smaller containers to isolate any damage. Tubes still have an application and the techniques developed at North Kirra have been utilised on other tube projects.

2.2 Maroochy River Groynes

Project location: Maroochy River, Maroochy, Queensland

Date constructed: 1994

Principal: Maroochy Shire Council

Description: 50m long x 4m high sand filled groyne

Site Conditions: The southern bank of the Maroochy River is a popular tourist destination, fronting a large Council operated caravan park which has suffered severe erosion since the 1980's.

Project objectives: To put in place appropriate mechanisms to impede the increasing erosion and river alignment. (Full details of the investigation are covered in the paper by Coughlan and Mootoo [1995]).

Community requirements and constraints: To ensure the nourishment and stabilisation process provided a 'user friendly' amenity without spoiling the natural beauty and popularity.

Construction techniques utilised to achieve objectives:

Two substantial groynes were constructed utilising sand filled geotextile tubes. Each groyne was fifty metres long and the design incorporated an extensive foundation layer to counter potential scour as indicated in the physical modelling.

The constructed height of over 4.0 metres utilising a multiple stack of 1.2 metre diameter tubes, incorporated a 40kN/metre geogrid in the foundation layers and first layer, fully encapsulating the respective layer to prevent the possibility of lateral displacement.

The tubes were manufactured utilising Terrafix[®] 1200R, polyester needle punched geotextile, and were filled by Council day labour work crews in conjunction with planned sand nourishment. Council opted to encapsulate the two groyne structures in a grout injected mattress for additional resistance to vandalism and pedestrian traffic.

Materials used: Terrafix[®] 1200R & geogrid

Evaluation and Comment: Six years after installation, the groyne structures are performing in accordance with the design expectations, and the amenity of the area is vastly improved.

2.3 Stockton Beach

Project location: Stockton Beach is located to the north of the Hunter River trained entrance in Newcastle.

Date Constructed: 1996

Principal: Newcastle City Council

Description: 48mlong by 45m high revetment constructed of sandfilled non woven geotextile containers with a mass of just under 2t was built on a 1.5H:1V repose with an extensive self healing toe.

Project Objectives: To provide temporary erosion protection to the Surf club.

Site Conditions: Exposed ocean beach.

Materials used: Terrafix[®] 800RX geotextile

Evaluation and Comment: This was the first of the engineered sandbag revetments constructed to protect oceanfront properties. The option to construct in this manner was largely influenced by the uncertainty of the long term approved solution for the site and the amenity of the brick and concrete surf life saving club. Sand filled geotextile units were filled and placed by Council day labour crews, with the assistance of an excavator utilising a modified rock grab.

Despite the “temporary” nature of the structure, the non-woven geotextile containers have withstood a number of storm cycles over five years of service. This installation has outlived the original design requirements and met the objectives of protecting the surf club whilst complying with providing a ‘soft’ interim solution to the total coastal management problem at this site. The success of this revetment has lead to a number of other areas such as Belongil Spit at Byron Bay, Airlie Is in W.A, Troubridge Is in S.A. utilising similar site appropriate techniques.



Figure 1 - Stockton Beach Surf Club

2.4 Narrowneck, Gold Coast

Project location: Narrowneck is situated on a narrow isthmus between Surfers Paradise and Main Beach, Gold Coast, Queensland

Date Constructed: 1999-2001.

Cost: \$2.5M (The cost of rock was estimated at ~\$5M)

Site conditions: Easterly facing open surf beach with an offshore max wave height of >12m.

Project objectives: The reef is an integral part of the Northern Gold Coast Beach Protection Strategy whose aim was to widen and protect the northern beaches as well as enhancing the surfing amenity. The reef will provide a low profile, near shore control point to retain approximately 80,000m³ p.a. of the 500,000m³ p.a. of sand transported to the north along this shoreline.

Community requirements and constraints: The public supported a user friendly structure. A condition of approval was for modification and even total removal if required. The mega sand containers facilitated these requirements.

Construction techniques utilised to achieve objectives: Nearly 400 mega sand containers varying from 3.0 metres to 4.6 metres in diameter, were placed using a split hulled, trailing suction hopper dredge fitted with computer interfaced DGPS. The containers were accurately filled utilising a calibrated density metre, ensuring repeatability and consistency of the construction.

Materials Used: The mega sand containers were constructed from heavy duty polyester Terrafix[®] non woven geotextile.



Figure 2 - Narrowneck Artificial Reef Aerial View

Evaluation and Comment: The ability to fill to a pre-determined shape and accurately place very large geotextile containers at a very low unit cost was conclusively proven. Damage occurred to some bags during laying and very effective underwater patching techniques were developed. Various coatings were trialled for the crest bags with mixed success but towards the end of the construction a durable composite material was developed and tested with great success.

Although some top up is still required, monitoring has shown a clear salient at times and enhanced surfing conditions. The results from the techniques developed for this project have given confidence for other reef projects such as at Noosa to proceed.

2.5 Maroochyore Beach

Project Location: This beach is located at the dynamic mouth of the Maroochy River, Queensland intersected by Pincushion Island.

Date Constructed: 2000-2001

Principal: Maroochy Shire Council

Description: 200m. long by 2.5m high revetment constructed of sand filled non woven geotextile containers with a mass of just under 2t.

Site conditions: The mouth, continuing a trend identified in the late 80's and early 90's, reverted to a more southerly discharge. During November 2000, the erosion problem on Maroochy Beach had propagated to such an extent that the foreshore and caravan park were likely to be threatened during the imminent cyclonic season and king tides.

Project objectives: Interim protection measures to stabilise the foreshore.

Construction techniques utilised to achieve objectives: Utilising two small excavators, (5 tonne and 8 tonne), 3000 non woven geotextile units were filled and placed as a defence barrier in the dunal system.

Materials used: 2 tonne Terrafix[®] Soft Rock[®] geotextile containers utilising Terrafix[®] 800RX staple fibre non woven geotextile

Evaluation and Comment: During the early months of 2001, king tides repeatedly tested the interim defence barrier. Observations of direct overtopping during consistent 2m wave attack, proved that the stability of such structures was higher than expected. Such conditions would have resulted in a failure of a conventional rubble design. The works are now to be extended using 4.5t sand filled containers to construct a 100m long groyne. The composite geotextile developed for the Narrowneck reef project is to be used for minimising risk due to vandalism.

2.6 Russell Heads

Project Location: Russell Heads (Woolamaroo South), North Queensland. Bounded by Mutchero Inlet River mouth at Constantine Point.

Site Conditions: Russell Heads is a fragile residential peninsula that has endured sixty years of recorded erosion influenced by a dynamic river system and seasonal cyclones.

Project Objectives: Community based program to construct hydraulically filled tubes progressively as a beach stabilisation structure.

Community Requirements and Constraints: The comparatively remote location limited resources and lack of government funding presented a serious dilemma for the small Russell Heads community. By combining their resources, they constructed a small dredge enabling them to install hydraulically sand filled tubes and nourish the beach in a series of progressive “working bees”. This program has continued for a number of years.

Materials Used: 1.2m diameter Terrafix® 1200R geotextile tubes.

Evaluation and Comment: The results of the resident’s actions have been positive. Several houses were saved as a result of these works during cyclone Justin in 1997.

Although the wave climate was such that some damage occurred, the inherent flexibility of the non woven needlepunched material utilised enabled re-alignment and settlement to follow scour contours and continue to provide stabilising protection.



Figure 3 - Russell Heads

3. SUMMARY AND CONCLUSIONS

The North Kirra groyne provided much confidence in the use of this type of structure. Subsequent benchmark projects have avoided mistakes made on the Kirra project and developed better design, fabrication and installation techniques. The proposed Maroochy groyne to be constructed late in 2001 will see a new generation of geotextiles, fabrication techniques and filling methods for groyne construction. The Narrowneck reef project has proven the practicality of constructing submerged reefs for beach protection and recreation.

The results to date indicate that:

- Geotextiles structures can be successfully used to solve conventional coastal problems and non conventional challenges.
- Non woven sand filled geotextile structures adapt and conform readily to changing site conditions.
- Design and construction approach requires specific consideration of site specific conditions and geosynthetic techniques
- Durability is often higher than anticipated by designers with decades of successful experience which continues to improve with advances in geosynthetics and related polymer science.
- Sand filled geotextile forms can create an excellent foundation for a broad diversity of marine species.

- Total constructed and life cycle costs are usually considerably less than traditional materials
- In case something goes wrong in the complex field of sandy beach systems, the geotextile sand containers can be easily removed compared to other structures.

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