ENVIRONMENTAL BENEFITS OF SAND FILLED GEOTEXTILE STRUCTURES FOR COASTAL APPLICATIONS

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ABSTRACT

Continuing coastal erosion across the world is leading to the development and installation of innovative techniques for the effective and unobtrusive shoreline and near shore control. This paper looks at a variety of coastal structures built utilising only sand filled goesynthetics over the last fifteen years.

INTRODUCTION

The use of sand filled geotextile units as permanent construction elements in coastal works as a replacement of rock or concrete armour units elements is already more than 50 years old. With the increasing cost of the "conventional" construction materials and environmental awareness of coastal engineering activities, the use of sand filled geocontainers and tubes especially made of nonwoven staple fibre geotextiles has increased. Sand filled geocontainers and tubes forming "Soft Rock Structures" have proven to have significant environmental advantages over conventional "hard" rock, so that they have also been used in areas where rock is readily available at a reasonable cost. A number of case studies of significant projects from Australia and overseas are presented.

CASE STUDIES

Groyne – North Kirra, Gold Coast, Australia

This project pioneered the use of multiple, large diameter tubes in Australia. The structure was designed as a temporary structure for a design life of 5 years as an erosion protection groyne. Despite some initial damage by vandalism, this structure is now over fifteen years old and has been covered by sand nourishment. As a result, a number of other structures in a variety of configurations were constructed in the Gold Coast and other areas.

Groyne – Maroochy River, Sunshine Coast, Australia

In 1994, two major groynes were constructed in the Maroochy River on the Sunshine Coast following extensive model testing and studies by the Coastal Management Branch of the Department of Primay Industries. The Maroochy Shire Council constructed these groynes to protect the badly eroding northern shore of the popular Cotton Tree recreational holiday caravan park. The multi layered Terrafix® geotextile tube groynes utilised extensive sand filled tubes in the scour protection layer, as well as extensive use of high strength geogrid encapsulating the multiple tube layers of the groyne.

The performance of the groynes has been a resounding success both in terms of maintaining the renourished beach area, but also in terms of creating a very low impact, user friendly and unobtrusive structure. The recreational facility of the caravan park maintained operation during construction and has been significantly enhanced since completion.

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Reef – Narrowneck, Gold Coast, Australia

On the Gold Coast of Australia, construction of a submerged reef has been included in the $A8.5M strategy being implemented to protect the Northern Gold Coast beaches. This reef has been designed to widen and protect the beaches and also to improve surfing conditions. Extensive numerical and physical modeling of this reef has been possible. Cost benefit studies also have been carried out and the $A2.2m reef is expected to pay for itself in less than a year.

To be as surfer friendly as possible at a reasonable cost, an innovative construction methodology using large prefabricated geotextile containers filled from offshore in a dredge hopper was developed for the project.

This method has the following benefits:

- ✓ able to achieve design shape
- ✓ 50% cost of rock (hard rock)
- ✓ surface reduces risk of injury to surfers
- ✓ no rock haulage and impacts on roads or users
- ✓ flexible to cope with seabed movements
- ✓ no works on beach or impact on beach users
- ✓ able to be easily topped up, modified or removed if necessary (important for approvals).

To achieve as accurately as possible the design shape, three different sizes and shapes of sandbags ranging from 20m long x 3m diameter (150t) to 20m long x 4.6m diameter (400t) are being used. Also the bags are being monitored accurately after placement and the bag layout modified by International Coastal Management as construction progresses. The present design uses over 300 sandbags to construct the reef. The contractor, McQuade Marine, is using a shallow draft hopper dredge, „Faucon“. Construction of the reef began in August 1999 and completion is expected in mid 2000. The bags are being designed and manufactured from non-woven staple fibre geotextiles manufactured on the Gold Coast by Soil Filters Australia, forming a coastal engineering structure.

The construction method consists of

- ➢ unrolling a prefabricated geotextile bag into the dredge hopper,
- ➢ the dredge hydraulically fills the bag with sand,
- ➢ when filled, the bag inlets and outlets are sealed,
- ➢ the dredge positions itself above the exact location for the bag, opens the hopper and drops the bag.

Stockton Beach, Newcastle, NSW

During 1996 the Stockton Beach Surf Life Saving Club was threatened by extensive dunal erosion to the point that either the brick and concrete structure would have to be completely located, or a sea wall constructed to prevent further erosion.

The total coastal process was under investigation and as such the local council, in conjunction with consulting engineers WBM Oceanics, elected a cost effective sea wall constructed from durable non-woven staple fibre sand containers. In all a total of 460 units were placed on geotextiles to construct a sea wall during November 1996. The wall was constructed using council day labour crews, a backhoe for filling and an excavator for placement of the units. The sea wall has performed admirably during a number of heavy seas and is still in service.

Belongil Spit, Byron Bay, NSW

Residents of Belongil Spit at Byron Bay had been fighting a losing battle against accelerating erosion of their prime ocean front real estate. Study of the coastal process and implementation of a management plan was in its infancy when high tides during July 1999 threatened to claim a number of properties. Previous attempts to stem the erosion utilising hay bales and up to 25,000 small hessian sand bags had proved unsatisfactory.

Byron Bay represents a unique region renowned for its mix of famous residents, as well as alternative lifestyles. The importance here has been to provide a low impact, environmentally friendly solution utilising sand filled geotextile containers. Over 1500 geocontainers have been filled and placed by a combination of local government day labour, contractors and willing residents.

Island of Sylt, Germany

At the beginning of 1990, a series of storm tides had caused severe erosion to the west coast of Sylt. After this event, the historical house "Kliffende", located near Kampen at the west beach of Sylt, was only 5.40 m away from the edge of the cliff – in the 1920s it was built in a distance of about 80m from the edge of the cliff. There was a big danger that the west gable of the house "Kliffende" would fall into the sea during one of the next storm tides and that the house would thus suffer irreparable damage.

The authorities indicated to the client at the time of the initial planning that solid (massive) constructions methods, for instance a stone revetment or a barrier (protective wall) made of concrete shaped bricks would not be permitted due to the location in the nature reserve. For this reason rigid constructions (hard rock) were regarded critically.

On this basis, the consulting engineers developed a new system consisting of geotextile "sand cushions". The installed geotextiles fulfil two requirements. On the one hand the geotextiles function as a filter-effective protection against sediment wash-out and on the other hand the terraced layered geotextiles work as reinforcement for stabilisation of the dune embankment.

In combination with beach nourishment this construction was designed as "2nd defense line" and sand should be covering the structure again after severe eroding winterstorm periods.

A very specially designed needle-punched composite material – produced by Naue Fasertechnik – consisting of a polypropylene slit film woven and a polyester non-woven was selected.

The achieved total height of the construction is 8m with inclinations of (V:H=) 1:2 in the lower and (V:H=) 1:4 in the upper cross section area.

The seaward faces of the sand cushions were accurately formed with the aid of concrete shuttering elements. The excavated material from the sand re-nourishment was re-deposited on the geotextile strips and carefully compacted. The free end of the geotextile strips was folded back and the concrete shuttering removed. In the meantime, the sand cushions laid on top of each other to form a stabilized beach section.

Transverse bulkheads were provided by installing fabric/non-woven sheets in order to counteract possible scouring of sand from the sides in case of partial damage to the construction.

The structure proved worthwhile several times during winter storms in 1993 and 1994. The geotextile construction was exposed during these storm tides, but not damaged.

The Terrafix Soft Rock® construction even survived the second largest storm surge at the west coast of Schleswig-Holstein on December 3 and 4, 1999, showing superior effectiveness compared to all other structures being used on the island. Thus the geotextile structure survived storm surges with a still water level at 2.5m above normal and severe wave action which could reach more than 5.0m.

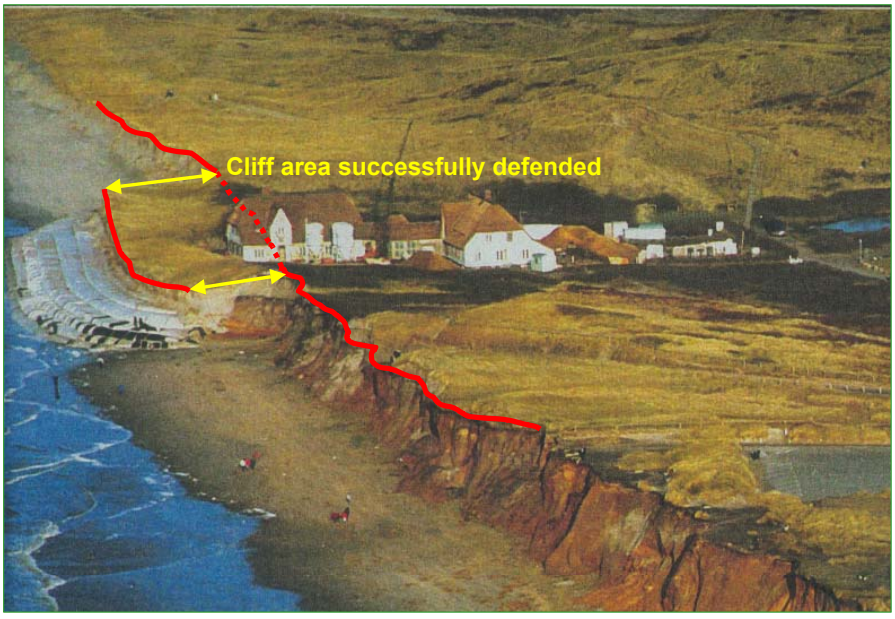

Figure 1 : Defended cliff area with geotextile "sand cushions" on the Island of Sylt, Germany

Sri Lanka

In 1992, 60 kilometres north of Colombo/Sri-Lanka, single beach sections were affected by coastal erosion. With the monsoons in force the local church and houses were in danger of being lost to the sea. The local Coast Conservation Department together with the GTZ (German Agency for Technical Cooperation) decided to install 800 sand containers placed like interlocking bricks along the beach in front of the church to save the shoreline. These 1.35m x 2.65m large sand containers (800 kg weight) were manufactured from non-woven geotextiles and filled up with $1m^3$ locally available sand. The simple installation equipment consisted of a locally built sand hopper and tractor. The high elongation and durability of the containers (mass per unit area = 800 g/m^2) have shown excellent resistance to abrasion due to the large number of short fibres acting like bristles of a brush. Finally, the fast and simply handled construction method provided immediate protection to the endangered church.

Eider Storm Surge Barrier, Germany

The river Eider is one of Germany's most important outlet channels into the North Sea. The Eider estuary is protected against storm tides by the storm surge barrier Eidersperrwerk, which was constructed in the early 1970s. Flexible and rigid bed stabilizations were arranged on both the sea and the land side to avoid scour development towards the barrage. Temporary weir rehabilitation caused increased currents which accelerated scour development. The flexible scour embankment was destroyed and could no longer fulfill its purpose to adapt to the edges of the scour and to protect the rigid bed against underscouring. The barrage was endangered by up to 30 m deep, unstable and very steep scours. In 1993 the scour embankment rehabilitation measures were started up. Due to the steep scour geometry ordinary construction methods were not possible and the use of geotextile tubes or cushion mats also had to be ruled out, since one failure could possibly paralyse several functions. Therefore 48,000 sand containers ($1m^3$ fill volume) were successfully installed as a filter construction on the existing scour embankments. 204 non-woven sand containers were installed per barge in 1 hour by the use of a hydraulic dredger (Figure 2). Less than 10 of the total 48,000 geotextile containers were damaged during their placement. The negative experience with some woven geotextile containers, used in former projects, was not apparent at that time, and it is the opinion of all involved persons that future preferences will be given to containers manufactured from needle-punched non-woven fabrics.

Figure 2 : Filling and loading of sand bags at Eider Storm Surge Barrier, Germany

SOFT ROCK STRUCTURES – NONWOVEN GEOTEXTILE CHARACTERISTICS

Sand filled geocontainers and tubes forming "Soft Rock Structures" have proven to have significant environmental, but also technical advantages over conventional "hard" rock.

To achieve this success with geotextile "Soft Rock Structures" various disciplines needed to cooperate and special attention had to be paid to the seams and the prefabrication of the inlets and outlets for the filling process. Special threads and stitching methods were used to achieve a strong seam with sufficient flexibility, however, for the prefabrication of the mega sand bags. The selected heavy needle-punched non-wovens prevent stress peaks in the geotextile due to their high elongation performance and provide very high installation robustness.

The fibre structure of the thick needle-punched non-wovens also guarantees the given coarse, open pore surface for the embedding of sand and the settlement of marine life. Non-wovens protect themselves against abrasive attack of sand in the breakers zones by migration of sand into the pore structure. In contrast to wovens, the given fibre structure of non-wovens leads to attachment of marine life after a few days. This has been observed during diving surveys checking the installed sand containers. A real reef life and environment was created e.g. at Narrowneck, Gold Coast, Australia, within a few months only. The mega sand containers are already covered with 30 – 40cm long algea and a lot of fish shoals and even shrimps have settled.

Table 1: Main characteristics of used geotextiles for Narrowneck Reef

Staple fibre non-woven, mechanically bonded and needle-punched	
Raw material	UV stabilized polyester
Mass per unit area	1,200 g/m²
Thickness under 2kPa load	5.5 mm
Maximum tensile strength	>38 kN/m longitudinal and >65 kN/m transverse
Elongation at break	>80% longitudinal and >50% transverse
Opening size $O_{90,w}$	0.09 mm
Roll dimensions (width/length)	w/l = 4.0 m / 50.0 m

CONCLUSION

In respect to enhance the natural capacity of the coastal environment and also the economic aspects referring to coastal tourism, the construction of "Soft Rock Structures" made of non-woven needle-punched geotextiles represents a global unique coastal engineering approach. In light of negative influences on sediment dynamics at sandy beaches using non-flexible coastal structures made of concrete or rip-raps, geotexile solutions fulfill the demands on flexibility.

Terrafix Soft Rock® Structures for flexible coastal structures are providing versatile applications with guarantee on high performance in variable morphology, environmental acceptance and long-term sustainability.

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