Case Study: Long-term Effectiveness of Geosynthetic Sand Containers at Umdloti Beachfront, 8 Years Later.

R. B. Langer[1]

Fibertex South Africa, Hammersdale, Kwa Zulu Natal, ryla@fibertex.com

Abstract

Extreme storm events and unusual tide variances has resulted in extensive damage along the South African east coast. This paper highlights the rehabilitation of the flood damaged areas at Umdloti beachfront using Geosynthetic Sand Containers (GSCs).

GSCs in this case study have proven to be a cost effective and simplified solution to better protect the coastline from future weather events. GSCs are considered a suitable alternative when compared to traditional defence systems such as concrete block walls, tetrapods and gabions. GSCs are commonly referred to as a soft solution that promotes environmental sustainability whilst possessing adequate mechanical strength against severe weather conditions faced at Umdloti. The solution promotes the use of insitu fills along the coastline opposed to imported fill material subsequently reducing the construction carbon footprint. The paper indicates mechanical and durability requirements that GSCs should possess to perform effectively as beach erosion control. The Umdloti GSCs have been installed for approximately eight years and have proven effective in preventing the beachfront against further damage. While the GSCs have integrated seamlessly into the beachfront environment, the system continues to maintain its functionality by way of adequate material durability.

Keywords: *Geosynthetic Sand Containers (GSC), Storm tides, coastal protection, environment, erosion*

1. Introduction

Devru Construction (contractor) was appointed for the rehabilitation of the Umdloti beachfront embankments in 2017. The beachfront was severely damaged by heavy rainfall resulting in localised flooding. High tide conditions caused an under sour erosion phenomena leading to the collapse of the concrete block retaining wall that acted as an erosion measure for the adjacent road. The collapse caused major route disruptions along the beachfront and posed as a public safety concern. The contractor had to provide a suitable solution that would be able to withstand the negative effects of future storms within a timeous manner. Due to the issue of accessibility, the conventional solution of a concrete block wall was excluded from consideration. Tetrapods or tetrahedral concrete structures (dolosse) were ineligible due to high cost and extensive manufacture times. Other solutions discussed were that of rock-filled gabion baskets subsequently ruled out due to its low durability issues seen along many coastlines.

Softer solutions such as infilled geocells with shallower slope gradients were considered but could not provide a permanent solution against erosion unless vegetation was guaranteed. The geocell solution also required the import of specialised fill material hereby-increasing costs for an unbudgeted project. The use of GSCs was considered due to its durability in other marine applications around the globe. The GSCs used at Umdloti were required to perform as well or better than traditional methods of erosion protection. Further investigation found that GSCs could perform as a mass gravity wall when installed and designed accordingly. The paper will focus on the rehabilitation of the Umdloti beachfront using GSCs by way of comparison to conventional hard solution, desired material properties and preferred installation techniques.

2. Comparing two coastal protection solutions

2.1 Concrete block walls as coastal protection

The collapsed concrete block wall used at the Umdloti beachfront proved inadequate against the rising tide level. This could be that the system used outdated soil reinforcing techniques or the possibility of the geosynthetics used for separation in the concrete block wall were not compatible with the retained fill material causing a clogging effect. Other issues that could have led to its failure would be the founding level of first row of blocks.
Constructing foundations for concrete block walls in coastal areas can be costly, often requiring reno mattresses, concrete slabs or reaching bedrock in most cases. The use of geogrids further adds to expenses when stability is of concern. These measures further implicate on limited funds allocated for emergency works.
Less important factors include that of aesthetics when considering beachfront properties. Concerns of public safety when concrete block walls are undermined are growing. The event is sudden and could lead to injury when extensive wave heights cause block dislodgement.

2.2 Geosynthetic Sand Containers as coastal protection

Early geotextile containers consisted predominantly of tube-shaped infilled structures varying in length and circumferences manufactured predominantly from woven geotextiles. These tubes were hydraulically filled forming and elliptical cross section with a final height greater than 1 meter and a length greater than 20 meters. The tubes allowed rapid deployment over large areas while the woven geotextile provided relatively high strength at reasonably low cost.

Individual containers on the other hand are smaller units manufactured predominantly from non-woven geotextiles, designed for dry filling and considering hydraulic compaction. Individual containers are geotextiles sewn to form a rectangular cross section with a final fill height of less than 1 meter and length less than 3 meters. The geotextiles used in most cases are considered bi-component geotextiles.

GSCs for Umdloti made from very robust staple fibre geotextile layers sewn together with a UV stable polyester overlocked yarn. The Anti-Vandal layer is made from heavy, coarse, highly UV stabilised polypropylene fibres, which are designed to entrap sand particles and promote growth of marine vegetation. This action of sand entrapment enhances its durability characteristics by increasing the resistance to UV damage.

GSCs can be successfully used as coastal structures to solve conventional coastal problems due to the below characteristics:

- GSC-structures are more forgiving to wave action and coastal related hazards due to their flexible nature opposed to rigid systems (Table 2).
- They adapt and conform readily to changing site conditions and morphological foundation changes.
- GSC-structures are flexible and behave advantageously under cyclic hydrodynamic loads.
- GSC's are usually covered with sand or with marine or coastal flora, giving the structure a pleasant and "natural" appearance.

Table 1. Summarised comparison of GSC vs. CRB

GSC	CRB-Walls
Soft, flexible when filling	Rigid, interlocking system
Absorbs and diffuses wave energy	Deflects Wave Energy
Unskilled labour force	Skilled labour force
Inclusion of "Dutch-toe" means that the bags at the bottom can settle without overall instability of structure	Under scouring leads to cracking, which leads to disintegration
Isolated repairs can be done	Repairs are difficult for isolated areas
Blends in with environment and can be covered with sand and vegetation	Rigid concrete structures does not blend in with the environment; not aesthetically pleasing

3. Geosynthetic Sand Container Project Specification

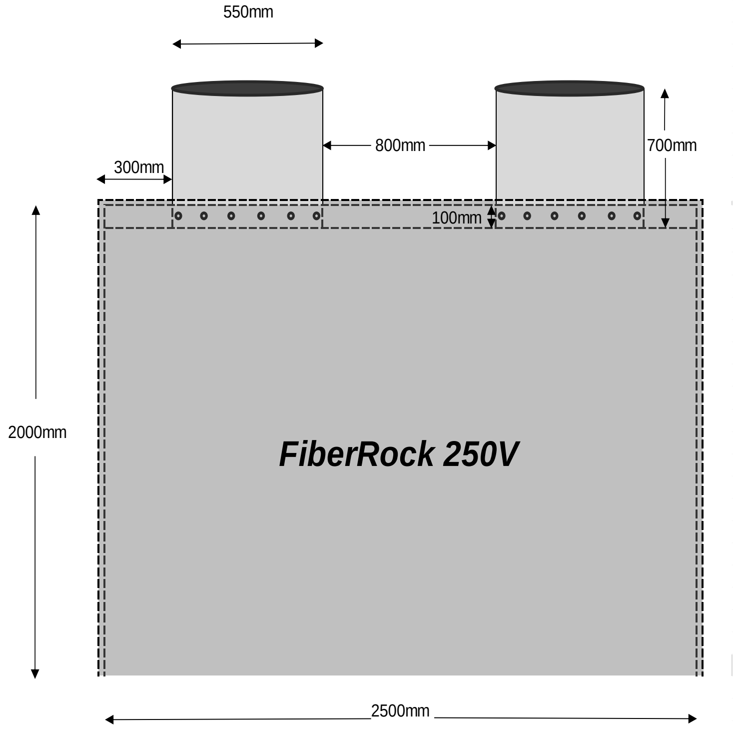

Figure 1: Drawing of GSC

Table 2 : GSC Mechanical Properties

PHYSICAL PROPERTIES		UNITS	VALUES	TEST METHOD
Mass (Combined for double layer)		g/m^2	1800	EN ISO 9864
Tensile Strength	Weaker Direction	kN/m	80	ENISO 10319-2008
Puncture Resistance	CBR	N	17 300	EN ISO 12236-2006
	Drop Cone	mm	0	EN ISO 13433-2006
Water Flow Rate	(@ 50mm head)	l/s/m2	15	EN ISO 11058:2010
Pore size	$O_{90\%}$	Micron	90	EN ISO 12956:2010
Abrasion Resistance	BAW Rotating Drum	kN/m	>60	BAW Abrasion Test
Seam Strength (Straight stitch with overlock)	Machine Direction	kN/m	> 35	ENISO 10319-2008
Retained Tensile Strength after UV Exposure	After 500 Hrs	%	>70	ASTM D4355

4. Infilling of GSC

4.1 GSC Filling:

Place two/three heavy-duty carrier straps in the filling frame at equal distances apart and at least 600mm from the edge of the filling frame. Place empty GSC in the filling frame and ensure that filling ports are facing upwards Place filling hopper on top of filling frame and secure to frame. Position and secure filling ports around the hopper funnels, ensure strap is secure around filling funnel. Fill the GSC to capacity with a combination of sand and water. The quickest filling method is with an excavator, alternating two buckets loads of sand with one bucket load of water. The water will filter through the bag, hydraulically compacting the sand in the process. Once filled, roll the chute into the GSC and close through the loops with the rope supplied. If preferred, a slurry pump can be used to fill the bags instead of an excavator (described below)

4.2 Hydro filling (Slurry pump):

Pump saturated beach sand with a slurry pump and feed through to GSC hopper. If needed, wash down sand in hopper with water (scooped or hose fed). Ensure that the GSC is filled to capacity. Roll filling port into GSC chute and close the chute with the rope supplied with the bag.

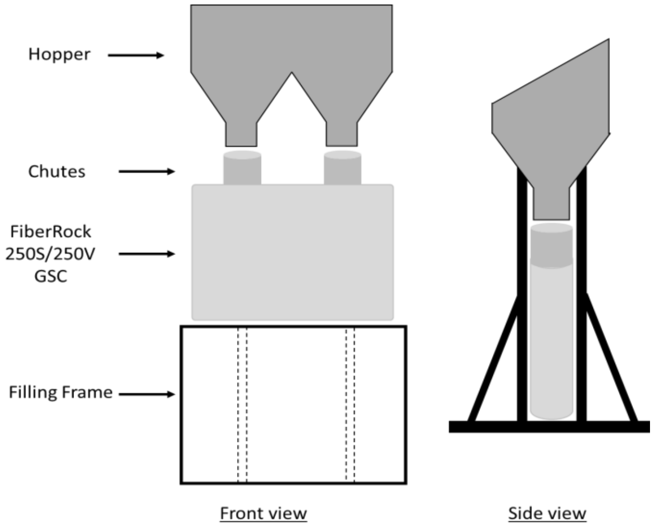

Figure 3: Hopper, frame and GSC assembly

4.3 Filled GSC Handling:

Ensure all strap loops are securely hooked around the carrier plant's (excavator/ loader) bucket teeth. Ensure GSC bag is free from obstructions before commencing the lift procedure. Ensure that people on site stand at least 10m away from the excavator before lifting the bags. Gently lift GSC bag out of filling frame in a vertical motion. Once suspended from the filling frame, the excavator moves the GSC from the filling frame to the installation location.

Figure 4: a) empty GSC installation in filling frame; b) filling hopper installed on frame; c) GSC filled with sand; d) lifting GSC out of filling frame

5. Placement of GSC

Step 1 Pioneer first line of first row

Ensure designated placement area is clearly demarcated. Establish and place first line (runner bond) of GSC structure by gently lowering the GSC onto the beach, ensuring adjacent GSC bags are well aligned and placed snugly together. This is to close all voids and reduce material washout that might cause future structural instability.

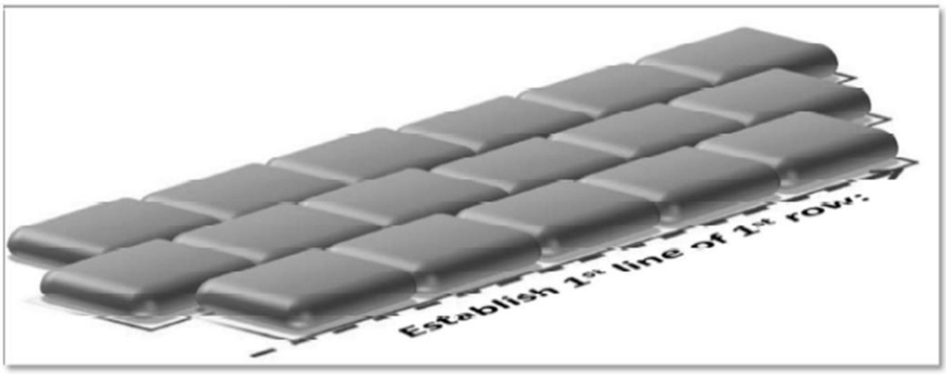

Figure 5: GSC Pioneer row placement. (HPGSC)

Step 2 Placement of second line of first row

Place the second line snugly against the first line, ensuring a staggered formation between the first and second lines to avoid GSC joint alignments that could lead to future structural instability.

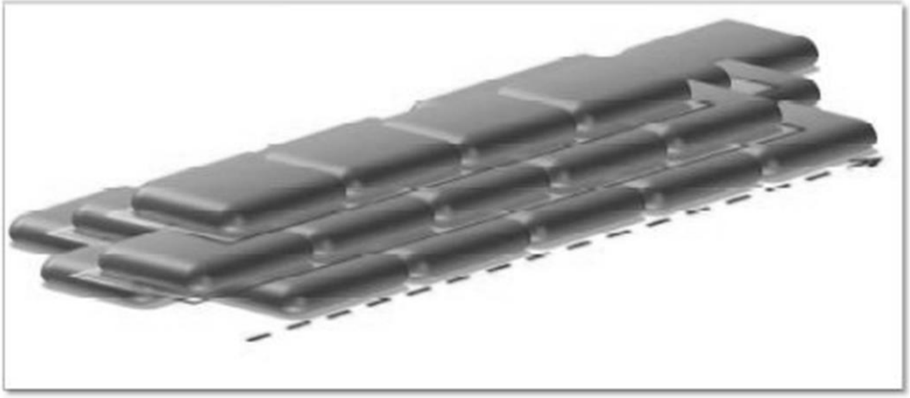

Figure 6: Placement of second and third layers of bags.

Step 3 Placement of third line and any further base rows

Place the next line of GSC's snugly against the previous line, ensuring a staggered formation between the current and previous lines to avoid GSC bag joint alignments that could lead to future structural instability.

6. Conclusion

The GSC solution was the preferred coast protection material for the Umdloti Beachfront project. Traditional methods may no longer be cost effective or have become environmentally unacceptable. GSCs offer soft engineering solutions that integrate into the environment whilst still offering a cost effective but durable solution. In harbour/ marine engineering, advances in GSC as temporary form works enable use in challenging conditions, where traditional construction methods might no longer offer the long-term benefits they did before. GSC is a simple geosynthetic product that can offer advanced soft engineering solutions.

One of the challenges on the project was lead-times of the GCS supply to site. The production process is manual and the bags are sewn by hand. For the Umdloti Beachfront project, we were able to ensure that there was a consistent supply of bags to site with good communication and planning Due to the high tides at night, the client was able to use some of the GSC bags to build a cofferdam. This allowed contraction activities to follow on site without any interruptions. Most of the installation on site is done using a TLB and thus reducing handling by workers increasing the construction process.

The GSC's at the Umdloti Beachfront have been installed 8 years ago. Since then there has been regular tidal storms that have been occurring annually. The Beachfront and its infrastructure has been successfully protected, the bags have blended well into the natural environment covered by vegetation and sand. The public's interaction with the bags has been great with young children being able to play around the soft wall. GSC can be a long-term solution for coastlines as seen at Umdloti Beachfront and other areas that have used the technology.

References

1. Concrete Manufacturers Association. (2008) 'concrete retaining block walls', *Project Review - Hydraulic Applications*, pp. 1–9. Available at: https://www.cma.org.za/Publications/Retaining-Walls

2. Corvaro, S. *et al.* (2022) 'Hydraulic Performance of Geotextile Sand Containers for Coastal Defences', *Journal of Marine Science and Engineering*, 10(9), p. 1321. Available at: https://doi.org/10.3390/jmse10091321.

3. 'FSA - Data sheet_REV07.pdf' (no date). Available at: https://www.fibertex.com/sites/fibertex.com/files/2023-11/FSA%20-%20FiberRock%20250V_REV07.pdf (Accessed: 1 July 2024).

4. Recio, J. and Oumeraci, H. (2009) 'Processes affecting the hydraulic stability of coastal revetments made of geotextile sand containers', *Coastal Engineering*, 56(3), pp. 260–284. Available at: https://doi.org/10.1016/j.coastaleng.2008.09.006.