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Woorim beach protection – chasing the tide sand filled tubes vs. sand filled containers

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ABSTRACT: Emergency foreshore protection was required for a dune stabilisation project at Woorim, Bribie Island, Queensland, Australia. The project was given emergency status due to dune erosion occurring in close proximity to an existing road. Hard revetment structures, such as concrete or dumped rock, were considered unacceptable solutions because the area was situated at a popular beach in close proximity to a surf lifesaving club and would have had a significant impact on public amenity. Also, potential sources of quality rock were situated at a significant distance from the site. Therefore, based on the successes of similar sand filled geosynthetic structures on nearby Maroochydore beach, the use of Soft Rock® sand containers was initially recommended.

Two options were presented to the client, Caboolture Shire Council, for consideration. The first option consisted of individual 0.75 m^3 geotextile containers, which can provide adequate coastal protection for up to 10 years. The second option consisted of 1.2 m dia. 25 m long sand filled geotextile tubes.

This paper outlines the issues, which confronted the client and contractor and highlights the pros and cons of the two methods used on the project. An analysis of the failure of the tube option has been carried out, so as to provide future end users with information, which will help avoid similar occurrences. A post construction analysis of the final solution has been carried out which incorporates production rates and the performance of the system.

1 INTRODUCTION

The use of geotextile foreshore protection systems is still relatively new in Australia and as such there is still a great deal which can be learnt from projects of this nature.

The aim of this paper is to provide the end user with a comprehensive comparison between two different systems and guide the decision making process to ensure the best option is chosen to suit not only the site and application but also the equipment available.

2 DESIGN REQUIREMENTS FOR GEOTEXTILE SAND TUBES AND CONTAINERS

Design considerations for geotextile sand tubes and containers for this type of project include:

- Survivability;
- Stability.

Some of the factors needed to be considered for tube and container survivability are:

- UV resistance – has a significant effect on long term stability of structure in areas where UV radiation is high, such as Australia.
- Abrasion resistance – the tube or container needs to resist hydraulic effects of wave-borne sands, coral & shell fragments.
- Damage resistance – damage to the tubes or containers can occur from the following sources:
  - Wave borne objects (driftwood, boats)
  - Vandals
- Fines retention – hydro-dynamic forces can affect the ability of the tube or container to retain fine material.
- Permeability – the permeability of the geotextile determines how quickly water is drained from the sand in-fill and, therefore, how stable the structure will be under wave action.
- Seam strength – high stresses will be induced in the seams of the tubes or containers during filling and placement. The seam strength should be at

least 80% of the strength of the geotextile. The seams should satisfy the durability criteria of the structure.

The factors to be considered for tube and container stability are:

- Tube or container mass – tube or container mass is dependent on the wave climate of the site.
- Scour protection – the toe of the structure should be founded at a level where it will be unaffected by undermining. A self-healing, flexible toe detail will significantly increase the long-term stability safety factor.
- Container layout & proximity – tubes or containers should be placed as closely together as possible, to minimize voids, using a stretcher bond pattern, preferably in a double layer.
- Interface friction – For containers, this property is particularly important for the upper portion of the structure. The critical failure mode is sliding of the top containers from the structure.
- Elongation – Tubes or containers fabricated from high elongation geotextiles have good moulding and self healing characteristics.

The manufacturer of the geotextile sand tubes and containers for this project has undertaken an exhaustive regime of performance and comparison testing to satisfy the above requirements.

3 GEOTEXTILE TUBE OPTION

Due to economic constraints and the temporary nature of the project, the geotextile tube option was initially chosen for the emergency works based on the perceived cost savings of the system.

A number of factors impacted negatively on the tube installation, which individually should not have compromised the installation but when combined ultimately led to the rejection of the system in favour of a container system. The issues which lead to this decision are discussed below.

3.1 *Filling methodology*

Traditionally tubes of this nature were filled using a minimum 4″ dredge, however no such equipment was readily available and the contractor opted to use a similar sized sand pump. It soon became apparent that the discharge from the system was not sufficient to carry the fill material in suspension along the length of the tube (25 m). An auxiliary pump was then connected to the system to improve the flow through the system, which improved the situation.

3.2 *Fill material*

The fill material used for the tubes was medium coarse sand obtained from the exposed beach. This material had virtually no fines content, as such was highly permeable and provided very little material to block or clog the geotextile of the tube. This meant that the water which should have carried the sand along the length of the tube was dissipated through the fill material and the geotextile quickly which resulted in low water velocity and subsequent deposition of fill material.

3.3 *Water source*

The only water source available to the contractor was the open ocean and obtaining suitable feed from this source was extremely difficult mainly due to two factors, namely:

- Location of the uptake point, the tidal range and flat slope of the beach meant that the uptake point needed to be moved a number of times during the filling process. This also meant that the pumping head increased which reduced the efficiency of the pumps.
- The wave climate during filling, while wave conditions were mild during construction the uptake point was often in the surf zone. This meant that pumps often sucked air through the system which resulted in sudden drop out of fill material.

3.4 *Site safety*

The volume of water being expelled from the tube caused severe erosion at the toe of the 5 m dune which was inclined at between 30 to 45 degrees. This created an unsafe work environment and it was felt that lives of the site staff would be at risk should the construction methodology be maintained.

3.5 *Site logistics*

The nature of the site meant that no equipment could be left on the beach during high tide and that the bed of the structure had to be excavated prior to the filling and placement of each tube. The time required to mobilize the equipment and prepare the site meant that very little time was available to actually fill the tubes.

Factors 3.1 to 3.3 led to slow and inefficient filling of the tubes, which compounded the cost implications of the restricted tidal work window described in section 3.5. This cost blow out resulted in the change of design to the more conventional container option.

4 GEOTEXTILE SAND CONTAINER OPTION

Following these developments, the client abandoned the geotextile tubes in favour of the 0.75 m^3 geotextile sand containers. This construction methodology overcame the issues highlighted in section 2, details of which are presented below:

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4.1 *Filling methodology*

Containers are filled with moist to dry sand using a small excavator. The manufacturer supplied the filling frames and closure equipment.

4.2 *Fill material*

The containers were filled using the same material as for the tubes, however mechanical filling meant that grain size did not effect efficiencies.

4.3 *Water source*

No water is required for this construction methodology.

4.4 *Site safety*

The safety of site staff was not compromised as there was no erosion of the toe of the structure.

4.5 *Site logistics*

The amount of equipment required to facilitate construction of the revetment was considerably reduced and as such a larger construction window was available. The dimensions of the containers and the filling and placement methodology meant that containers could be filled while excavation to the founding levels was underway and as such no delays in construction were encountered.

A total of 1,300 containers were required to treat a 300 m long section of dune.

There were two types of geotextile sand containers used for this project:

- 0.75 m^3 standard container
- 0.75 m^3 standard container with scour flap

The scour flap attached to the container enabled a self healing toe to be constructed. The specification for the geotextile used in the container is shown below.

TYPICAL SPECIFICATIONS

Property	Value
CBR Burst	
Strength	7400 N
Elongation	70%
Drop Cone Puncture	H_{50} 10 300 mm
Resistance	D_{500} 6.3 mm
G-Rating	8700
E.O.S. Dry Sieve	<75 μm
Flow Rate	60 L/m^2/sec
Permeability	3.2×10^{-3} m/s
UV Resistance	80%
Abrasion Resistance	75%

5 NOTES ON CONSTRUCTION

5.1 *Equipment required*

The equipment required for construction consisted of:

CONTRACTOR SUPPLIED

- Small excavator for filling containers;
- Large excavator for placing containers;
- Modified grab attachment for handling containers;
- Labour for setting up and closing containers

MANUFACTURER SUPPLIED

- Filling frames;
- Closing equipment.

Construction commenced in December 2004 with Geofabrics Australasia and Soil Filters Australia providing this equipment, as well as on-site technical assistance and training during the project.

5.2 *Construction technique*

The construction sequence for the geotextile sand container structure is as follows:

1. Excavate toe of wall to desired width of structure;
2. Place Terrafix separation geotextile in excavation and along rear bench up to finished height;
3. Fill, close & position containers with scour flap at toe of structure, refer to Photo 1;

Photo 1. Placement of geotextile and initial containers.

4. Fill, close & position remaining standard containers using stretcher bond pattern up to 5 containers high.
5. Place sand to cover toe of structure, see Photo 2.

The face angle of the structure varied in places to suit site constraints but generally conformed to the angle of the existing dunes. The technique used to close the containers was a unique three stage process which ensured long term stability of the sand in-fill and durability of the container.

The typical production rate that the contractor was able to achieve, on this project, for filling, closing and placing the 0.75 m^3 containers, was approximately 80 units per day based on a daily production rate of 6 hours. These calculations assume a total working day of 8 hours with a daily allowance of 2 hours for commissioning and de-commissioning of equipment.

Photo 2. Completed foreshore protection structure.

6 CONCLUSIONS

The structure has performed well with a good natural build up of sand at the toe and at the face of the bags. The construction of the geotextile sand containers offered the following advantages over the geotextile tubes:

- simpler mobilisation of required equipment;
- reduced set-up time of equipment;
- less sensitivity to tidal effects;
- no hydraulic effects on surrounding areas from pumping;
- as discrete elements, less sensitivity to vandalism;
- simpler construction of self-healing toe.

In December 2005, the structure was subjected to a combination of storm effects and king tide surges. The geosynthetic structure remained essentially intact, even though significant erosion of the adjacent dunes occurred, see Photo 3.

Photo 3. Eroded dune adjacent to protection structure, southern end.

The Caboolture Shire Council, in conjunction with the EPA, is considering the further use of Soft Rock containers at other potential erosion sites within the Shire.

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