Monitoring of Geosynthetics in Coastal Structures in the Arabian Gulf Marine Ecosystem

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INTRODUCTION

With increasing scarcity and cost of suitable rock in areas such as the Arabian Gulf, sand filled geosynthetic (SFG) structures are increasingly being used as an alternative to rock and concrete. Even in areas where suitable rock is readily available at reasonable cost, safety and environmental benefits are encouraging use of SFG structures.

Coastal structures and artificial reefs constructed of rock or concrete provide habitat opportunities, but are considered to generally act as fish attractors rather than increasing the total fish numbers and diversity. The increasing use of sand filled geosynthetic containers for coastal structures has shown that the marine growth on this type of material, particularly the softer non woven types, is different from adjacent hard structures. In general terms, the growth on non-woven geosynthetics tends to be predominately soft macroalgaes whereas the harder woven geosynthetics, concrete and rock tend to be covered predominately with harder Arthropoda and Molluscs.

This paper reports on research to optimise the benefits to the local marine ecology and associated recreational opportunities by designing with appropriate geosynthetics. The term “geosynthetics” encompasses both “geotextiles” and the increasingly more complex “geocomposites”.

BACKGROUND

The first detailed monitoring and research into the marine habitat associated with SFG structures was carried out at the Narrowneck reef on the Gold Coast, Australia. This is a Multi-Functional Artificial Reef (MFAR) designed to provide primarily coastal protection and improved surfing. After construction in 1999, monitoring showed that, unexpectedly, an extensive marine habitat had been created and the reef also provided positive environmental benefits. The fibre-structure of the thick needle-punched non-woven geosynthetics used in the construction of this reef provided an open pore surface for the embedding of sand [armouring] and growth of a wide diversity of marine flora and fauna. [Jackson et al. 2004]. Observations by the Australian National Marine Science Centre indicate that “the biological communities associated with Narrowneck Artificial Reef appear to enhance biodiversity and productivity at a local scale and may also contribute to overall regional productivity.” [Edwards, 2003]. It was also noted that the species communities are substantially different to other natural reefs in the region with the presence of resident (benthic and demersal) fish and other species, such as juvenile prawns, abalone, turtles, lobster that are not generally observed on nearby natural reefs that were monitored to provide comparative data. Turtles are commonly seen grazing on the “turtle weed” and even porpoises have been seen feeding on the small crabs that live in the algae. As a result, the reef has become popular with locals for fishing, diving, snorkeling and spear fishing.

Photos 1 - 4: Turtle, kelp, long algaes and scad at Narrowneck.

ARABIAN GULF TRIALS

To determine if the results at Narrowneck are indicative of similar benefits that could be achieved in the warmer Arabian Gulf conditions, studies involving different geosynthetics are being carried out in the Arabian Gulf. Data has also been obtained from rock, concrete and steel structures near to the test site to determine the marine habitat that has been created by these structures and materials.

These results are being used to determine the best materials to utilise in order to include habitat creation as well as safety in the design of coastal structures such as groynes, seawalls and reefs. The tests are targeted at providing specific data for the design of the MFAR proposed by Dubai Municipality [Mocke et al. 2004]. This novel reef designed by Dubai Municipality coastal engineers is to provide:

- Coastal protection,
- A surfable wave break, and
- Ecological benefits (and thus diving).

As the crest of the reef lens is shallow for surfing and will be able to be stood on in mild weather by swimmers and impacted by surfers in swell conditions, the construction material has been specified as sand filled geotextile containers.

Tests were commenced in March 2005 to determine the diversity, or lack of diversity, relevant to the various geosynthetic styles with a historical application in marine applications. 3 different commercially available geosynthetics were initially chosen:

- A polyester staple fibre needle punched **non woven**
- A **composite dual layer** mixed denier needle punched **non woven**.
- A sample of split film high strength polypropylene **woven**

The samples were deployed at various depths near the proposed MFAR site off Umm Suqeim 2. The depths have been selected to represent critical depths on the proposed MFAR. For safety, the material used needs to avoid the large numbers of urchins that cover the nearby rock and concrete breakwaters. Also, to be successful as a dive reef, the marine habitat formed should provide for a wide diversity of marine life that is not present on the nearby rock and concrete breakwaters.

Photo 5: Sea Urchins on rocks at Umm Suqeim 2 Boat Harbour

Despite initial deployment in early summer, the most stressful season, rapid marine growth was observed. Preliminary sampling was undertaken after 4 months. The samples were retrieved by divers, divided in half and one half returned to allow for further development. Further visual inspections were undertaken at 7 and 8 months.

As expected, there was considerable difference between the growth on woven and non-woven samples. Predominate species identified after 4 months were:

- Woven (Photo 6):
  - Barnacles, about 90% coverage
  - Red algae, about 5% coverage
- Single layer non-woven (Photo 7):
  - Red Algae, >90% coverage
  - Ascidians (seaquirts), about 10% coverage
  - Crabs (2 species)
- Composite non-woven (Photo 8):
  - Red Algae, about 30% coverage
  - Ascidians (seaquirts)
  - Crabs
  - Barnacles (juvenile)
  - Annelids
  - Polychaetes
  - Sponges
  - Shrimp

Photo 6: Woven sample after 4 months

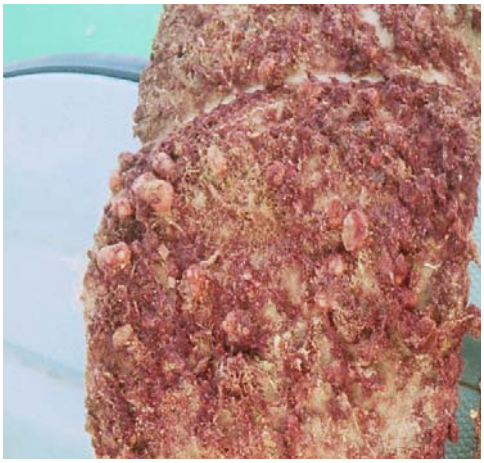

Photo 7: Non-woven, single layer sample after 4 months

Photo 8: Non-woven, composite layer sample after 4 months

A further custom sample was deployed during the 7 month observations. After 8 months the samples appeared similar although the non-woven, composite layer sample clearly showed a trend towards an increase in sponge type / sea squirt type growth and a decrease in macro-algae coverage (Photo 9).

Photo 8: Non-woven, composite layer sample after 8 months

RESULTS

Inspections show that rock and concrete structures are not providing any significant habitat improvement. This may be due to a predominance of sea urchins on these structures that limit the establishment of marine flora.

The results confirm that geosynthetics can be used as an effective substrata to increase biomass, particularly of important species such as prawn lavae.

The predominant “soft” growth on both of the non-woven geosynthetics indicates that either would be suitable for the shallow sections of the proposed surf reef. Additionally, the marine biologists considered that the crab population evident in these samples was likely to be responsible for controlling the incidence of urchins. While both non-woven geosynthetis provided habitat for good species numbers and diversity, the composite layer geosynthetic provided the most diverse habitat. As such, it would provide the best substrate for ecological enhancement and a dive reef. The “hard” growth and potential for urchins on the woven sample indicates that it is

not suitable for the shallow sections of a surf reef and would provide the least diversity for a dive reef.

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