Recent Applications of Modern Geosynthetics for Coastal, Canal and River Works

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ABSTRACT: The development of new, modern geosynthetic combinations increases the ease and the security in which engineers can design and construct coastal, canal and river works. Such combinations enable geotextile filters, for example, to be installed in deep moving waters without the necessity to place the cover material at the same time. This allows proper inspection of the filter before the cover layer is installed. The special combination of fabrics and mineral ballast needle punched together has been used successfully in several European sites.

Recently specially selected geotextiles have been made into highly robust and durable soil containers to prevent the scouring activity around underwater structures. This has proven to be an economical and reliable method to solve related engineering problems.

This paper discusses these special combinations and applications, some of the design factors for their use and selection and describes some of the sites where such combinations have been used.

1. INTRODUCTION

As soon as man-made structures are built in moving water short term and long term changes in the immediate and surrounding ground surface must be expected (Kohlhase 1992). This can take the form of scour near to the structure itself (e. g. around bridge piers and abutments) or erosion (e. g. down stream of a groyne). Erosion and scour can also take place naturally especially at sandy beaches exposed to waves.

Scour and erosion are caused by hydrodynamic forces especially within the transition areas between a hard structure and a moveable bed. When structures are built special considerations must be given to this problem. This problem is most especially noticeable with soils with high individual particle mobility (DVWK 1993).

The scour or erosion must be controlled by installing properly designed filters covered by usually large sized materials (stones, concrete blocks etc) to absorb the energy of the moving water (PIANC 1987). This moving water can be waves, natural currents (e. g. tides) or man made (e. g. down forces from ships propellors etc). These filters can be made from granular materials or synthetic materials such as geotextiles and they need to be properly designed. Their function is to keep the particles of the soil to be retained in place but at the same time not impede the movement of the water through the soil. Impeded water movement could cause increased pore water pressure which in turn could create loadings on the structure for which it was not designed. Installing these filters above water is relatively easy, especially controlling them. Underwater installation of filters is difficult to perform and control.

In addition, the armour stones can damage a geotextile filter if the geotextile is not properly selected.

2. SANDMATS

Usually woven goetextiles were used to make sandmats. Sand was pumped on site into pockets formed into the woven geotextiles. They were not easily moved when filled and they were difficult to fill under water. Additionally the relatively thin woven fabric was quickly damaged by abrasion.

The new generation of sandmats, Terrafix 1004 RB, are made from heavy duty flexible filter geotextiles with the sand placed between them in the factory and held in place across the whole mat by a needle punching process. The material is supplied in rolls as with other geotextiles and can be unrolled under water in water velocities up to about 0.5 m/s without the need for the cover layer to be installed immediately afterwards. This enables the overlaps to be controlled easily. By fixing a chain to the leading edge and flat bars every 5 m the Sandmat can be installed in water velocities up to approximately 1.0 m/s (Zanke 1992).

Tests carried out at the Bundesanstalt für Wasserbau (BAW 1991), Germany, have shown it to be an excellent retainer of soil particles. In the BAW Turbulent Water Filter Test, a filter is deemed to be filter stable when, after 150 mins, no more than 300 g has passed through it and in the last phase (120 mins - 150 mins) no more than 30 g should pass through it. For fine grained soils not many geotextiles can achieve these criteria. In the test with the Sandmat 42.8 g of fine grained soil passed through in total and only 4.9 g in the last phase.

The 4.50 m wide rolls of the Sandmat with its 5000 g/m² sand ballast can be installed by simply lowering it to the sea, canal or river bed and unrolling it using a spreader bar and an excavator. The excavator can be on the bank or afloat on a pontoon. Depending on the size of the pontoon the excavator can run along the pontoon unrolling the roll on the bed as it moves, the pontoon itself can be move, or the sand mat can be lowered from one pontoon and pulled along the bed to another pontoon. For larger scale work rolls of the Sandmat can be sewn together and rerolled onto large diametre steel pipes. So long as the water velocity is below about 0.5 m/s the Sandmat does not need to be covered with stones immediately. This allows time for the overlaps to be properly controlled by divers etc.

For water velocities above about 0.5 m/s either some stone cover layer must be installed with the Sandmat or chains can be fitted to the leading edge. This weight pulls the edge of the mat into any scour developing at this edge and thereby cutting off any further scouring. The mat is stable. If the conditions warrent it, flat steel bars can be fitted every approximately 5 m to the mat stop the mat from folding, especially when the mat is being pulled from one pontoon to another.

At Pielweichs, Germany, power generators were being built into the fast moving river. During construction of this power generation plant the river was diverted and a pond of still water created below the plant. Over 50 000 m² of the Sandmat was installed in this basin without a single cover stone installed. This enabled the Engineer to check the overlaps properly and the contractor to organise the placement of the stones at his own pace. The water depth was up to 3 m.

Groynes made from sand were installed in the fast moving River Elbe, Germany, on top of the Sandmat, where the use of a chain at the leading edge and flat steel bars secured to the sandmat every 5 metres was made. The mat was simply pulled from one barge to another (Fig 1).

A cable was installed over the soft silt of a Swedish lake. If the stones to protect the cable were installed directly onto the silt bed they would have disappeared into this soft silt. The sandmat was installed over the cable and silt, under water by divers and the stones were dumped from the lake surface onto the sandmat.

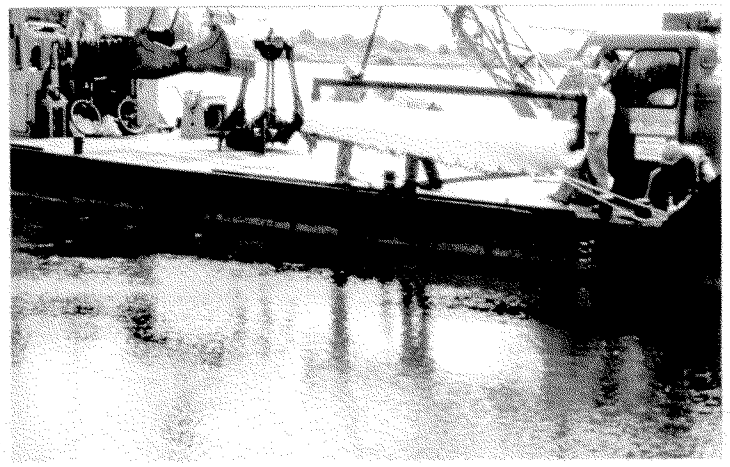

Fig. 1: Installation of the Sandmat, River Elbe, Germany

A new jetty was build at the Baltic sea harbour of Rostock. This jetty was designed to take large vessels and the water depth was 12 m. As much scour was expected from the ships propellors, a geotextile filter was chosen, covered by large stones. The contractor selected the Sandmat as the safest installed solution. He simply placed an excavator on a pontoon, the sandmat was stored on the jetty and the excavator, using a spreader beam, picked the rolls from the jetty, the pontoon was moved perpendicular to the jetty and the rolls were unrolled on the sea bed. An I beam was used to keep the end of the roll in place.

3. GEOTEXTILE CONTAINERS

Geotextile containers are often made from woven geotextiles because of the strength of the woven material. However using woven geotextiles for soil containers has several disadvantages:

- Associated with this high strength is a low elongation. This means that when these containers drop onto the reminants of a riprap, for example, they are likely to split, loosing their contents.
- The angle of friction between woven geotextiles is comparatively small. This may be important when woven sacks are being placed on each other.
- The permeability of woven geotextiles is often low. When the containers are dropped into water the air in the fill material cannot escape fast enough and the bags can burst.
- Woven materials are relatively thin and are quickly damaged by abrasion (Saathoff 1991).

Geotextiles containers made from staple fibred non woven material has the following advantages:

- The fabric can stretch when loaded enabling drop energy to be transferred through the fabric without it breaking.
- The material forms a good 3 dimensional filter so that the contents of the container do not wash through it (Heerten 1992).
- Due to the rough texture of needle punched geotextiles there is a high angle of frictions between the containers.
- The containers are flexible enough to move into any scour without breaking and are able to prevent the scour from developing.
- Staple fibred non woven geotextiles have very high permeabilities. Thus trapped air can escape from the containers quickly. Even so, when dropped into water special seams are required which reclose once the air has escaped.
- Staple fibres are usually crimped. This means that the individual fibres are wavy instead of straight. Thus within the structure of the material there are far more fibres perpendicular to the plane of the geotextile. These then act like the bristles of a brush, making them much more abrasion resistance.
- Work carried out in Germany between the University of Munich and Naue Fasertechnik showed that as the unit mass of a needle punched geotextile is increased, so too is its resistance to damage from dropping objects (drop energy). A graph showing the results of these tests is shown in Fig. 2.

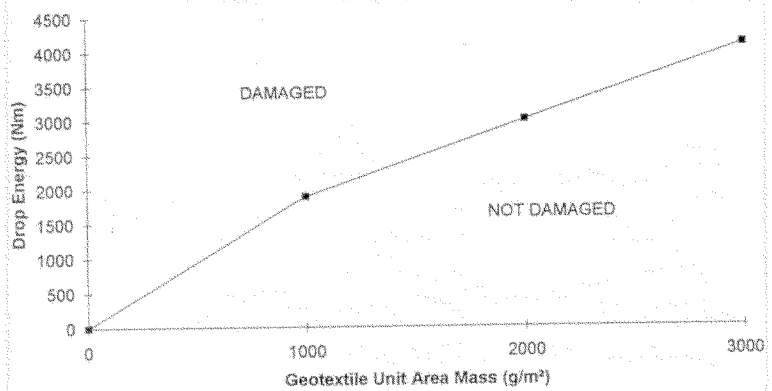

Fig 2: Geotextile Damage Chart

The 20 year old Eider Tidal Barrier, Germany, was designed with a semi rigid scour protection up and down stream of the barrier itself. This protection system failed and scour up to 28 m depth developed. It was decided that the scour slopes would be stabilised using 1 m³ non woven geotextile containers (Saathoff and Witte 1994).

Over 47.000 of these 1 m³ containers were used for this project. The geotextile used was a 550 g/m² staple fibred non woven PES one. In previous work the contractor had experienced 25 % failure rate with woven sacks. In this project the failure rate was under 0.25 %. Sophisticated filling machines were used so that over 700 containers could be filled per day (Fig 3).

In Sri Lanka the geotextile containers were being used as an emergency repair work because a church was close to being lost to the sea. Cheap local soil was filled into the 800 g/m² PES staple fibred needle punched geotextile containers using a simple, locally manufactured filling machine. About 60 containers were filled per day (Scheffer 1993).

Experience has shown that rock fill costing more than about DM/m³ 50.- installed can be replaced economically using robust needle punched geotextile containers.

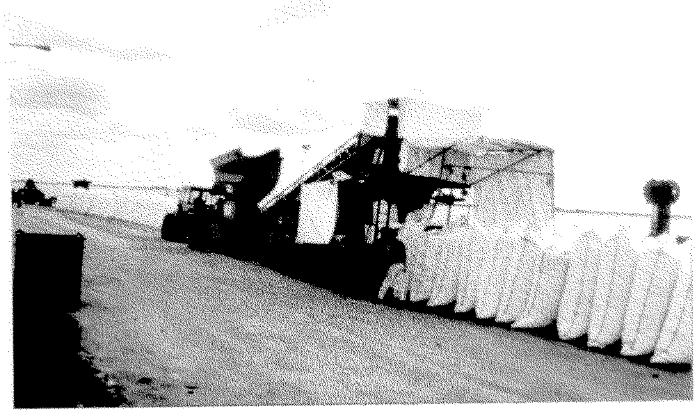

Fig 3: 1 m³ Soil Containers for underwater installation

4. POSSIBLE APPLICATIONS

The Sandmat can be used as an effective filter to retain especially difficult fine grained soils. Turbulent water tests on a volatile silt from Sweden showed that the Sandmat could retain this soil even though special two layered geotextile filters could not.

Any underwater installation of geotextiles can be replaced using the Sandmat. It is of special interest for deep water and other difficult installation sites.

Geotextile containers using heavy duty needle punched staple fibred geotextiles can be used to stop scour around bridge abutments, oil platforms etc.

The large sizes available means that they are stable in fast flow conditions and if not subject to external mechanical damage (e. g. from anchors, vandalism) or UV radiation (i. e. always under water) then no additional stone protection is required. They can also be used as a filter layer themselves. To ensure that the area is fully covered at least two layers are required.

The containers can be used to form the edges of a mole and sand could be hydraulically placed in this form. This could be of particular interest in fast flowing rivers where stone is not readily available, e. g. Bangladesh.

5. SUMMARY

Although it was felt that there could be no significant development of geosynthetics for waterway engineering, two new types have shown this to be incorrect.

The Sandmat - a ballast layer of sand held in place between two robust filter nonwoven geotextiles by a needle punching process across the whole mat - can be supplied in rolls and can be unrolled under water without requiring a stone cover layer to be installed at the same time. It also has excellent filtration values.

Heavy duty needle punched staple fibred soil containers in sizes of about 1 m^3 have shown themselves to be an economical way to install material under water and act as a filter layer.

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