By Stephen Martin

Geotextile Tubes Provide Coastal Erosion Protection in Ecuador

The El Niño warm-water phenomenon of 1997-1998 caused many weather anomalies around the world. From catastrophic flooding in South America to droughts in Indonesia and Australia to landslides in California, the environmental damages around the world will take years to heal.

El Niño was particularly devastating to the northern coastal areas of Ecuador that are popular with Japanese and European tourists. The monthly peak storm surge caused by the event was 3-5 m (10-16 ft.) above normal high tides. Many homes and businesses along Ecuador's beaches were destroyed, and its lucrative tourism and real estate industries received major economic blows.

In the village of Tonsupa at the confluence of the Rio Tonsupa and the Pacific Ocean, heavy rains and storm surges changed the course of Rio Tonsupa, threatening a stretch of homes and businesses. A simple, cost-effective solution, suitable for a third-world country, was needed immediately.

Possible Solutions

As the situation worsened, the government considered possible solutions. Sources of traditional materials, such as natural rock for riprap, are nonexistent in this part of Ecuador, and concrete can be very expensive and difficult to install. The Ecuadorian government, with the help of local engineering consultants, decided on high-strength geotextile tubes. Studies have shown that geotextile tubes have a far less detrimental impact on the environment by providing a "soft" solution to classic hard-armor alternatives. Designed to protect shorelines and beaches from the devastation caused by coastal storms, high-strength geotextile (HSG) Geotex tubes were used to protect against the erosive forces of nature.

Two types of HSG tubes were identified to meet the environmental conditions along Ecuador's coast. The tubes were constructed of either polypropylene (PP) or polyester (PET) high-performance fabrics and filled with dredged material from the river. Typically, river control structures are fabricated using polypropylene fabrics (within certain conditions), whereas breakwaters, groins, levee cores, and so on are made from high-strength polyester fabrics. When filled, the tubes attenuate wave energy, similar to natural sandbars. Along rivers and streams, the tubes provide resistance to the hydraulic forces that cause erosion and mass sloughing. Geotextile tubes are designed to resist abrasion, tearing, puncturing, and the pressures of pumping. In addition, they may be incorporated into the design of seaworthy dikes and breakwaters.

Installation

Synthetic Industries' engineers, together with representatives of GeoForm International, dredge manufacturer and dredging contractor, provided expertise and training for the local Ecuadorian contractor. The shallow draft dredge, equipped with a 1.5-m- (5-ft.-) wide cutterhead and a 20-cm- (8-in.-) diameter dredge line, was used to fill the tubes. One 50-m (164-ft.) polypropylene tube and five 100-m (328-ft.) polyester tubes were installed.

The polypropylene tube was a Geotex 4x6 HSG while the polyester tubes were constructed from Geotex 10x10 HSG. The scour aprons were made from Geotex 4x4 fabric. Scour aprons were positioned under the tubes to prevent piping or removal of soil below. Apron width was determined from information available from the US Army Corps of Engineers. The HSG manufacturer provided all necessary preliminary design calculations and follow-up technical assistance during installation.

The project began with the installation of a Geotex 4x6 PP tube, 4.6 m (15 ft.) in circumference and 50 m (164 ft.) in length. It was placed along the riverbank to redirect the riv-

er's flow away from the foundation of a hotel and downstream residences.

The second phase of the project involved the installation of 300 m (984 ft.) of Geotex 10x10 PET tube, 9.2 m (30 ft.) in circumference. These tubes were designed to receive the full force of the storm surge generated by El Niño.

Once dredge and pumping equipment was in place and working, the filling of the tubes proceeded rapidly. The Ecuadorian crew, unfamiliar with this type of new equipment and technology, installed 150 m (492 ft.) of tubes in two days. Placement of the tubes allowed natural aggradation of river sediments between the tube and the hotel's foundation, rebuilding the riverbank that had eroded away earlier that season.

The Geotex 10x10 tubes, 9.2 m (30 ft.) in circumference, were placed along the opposite riverbank, extending forth along the beach to absorb the energy of the El Niño–generated storm surge. Five 100-m (328-ft.) tubes were installed end to end for a total length of 500 m (1,640 ft.). The tubes will not only absorb energy from the storm surge, but will also allow beach sand to naturally be deposited behind the tubes, restoring the beach.

Protecting the Shore

It is expected that sand will continue to be deposited on the landward side of the tubes, providing further protection for the beachfront properties. In a developing country like Ecuador, it is important that erosion stabilization technologies be cost-effective and relatively simple to install. The consultant stated that Geotex tubes were the least expensive beach stabilization alternative available. Three months after completing the installation, the contractor reported that the tubes were continuing to protect the beachfront properties from the erosive storm-surge wave action. The success of the project will help protect homes and businesses and aid in restoring the tourist and real estate industries to this part of Ecuador. **EC**

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