EROSION CONTROL

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Battling Coastal Erosion

Holding back the sea with sand, mats, piling, and concrete

By Bill Tice

Coastal erosion is an increasing problem for shoreline communities around the world, and as governments, engineers, environmental groups, and the public all ponder the question of how to deal with a slowly eroding land base, some companies are developing innovative techniques to slow down or stop this mostly natural process.

According to the Texas Coastal Management Program (TCMP), the Lone Star State has one of the highest rates of coastal erosion in the US. Some areas of the Gulf Coast are eroding at rates of 5 to 10 feet per year, with an average rate of 6 feet per year. In extreme cases, such as western Galveston Island, erosion rates have been as much as 70 feet per year, and up to 42 acres have been lost annually to coastal erosion.

Preserving an Island

For Kevin Berry, whose family owns a private island in Corpus Christi Bay, those numbers were hitting too close to home. The Berry family island, which is 225 acres and sits 8 miles across the bay from the city of Corpus Christi, was losing 10 to 20 feet per year on the windward side to coastal erosion. Although the numbers are not as bad as those of Galveston Island, Berry was still concerned.

Photo: Crane Materials

Z-shaped vinyl sheet piling protects East Rockaway's waterfront.

"The erosion problem was just horrible, to say the least," explains Berry who—when asked how the family came to inhabit the island—jokingly replies, "Some people in Texas own a ranch; we own an island. We had tried various products over the years, but most solutions didn't hold up to the storms. We used sandbags as a temporary measure when we had failures, but with a 3-foot chop on a typical day in the Corpus Christi Bay, they didn't hold up for long."

The latest product Berry has installed is ShoreGuard 425, a U-shaped composite sheet piling product produced by Atlanta, GA–based Crane Materials International (CMI). The anchored ShoreGuard wall is tied back with a single whaler and armored with riprap, a solution that Berry says is working so far. "We did the installation last fall, and we are really happy with the results. The product is extremely thick and strong, it has a good face, it is stocked locally, has a 50-year guarantee, and it was easy to install. As far as I am concerned, we are now done with the windward side of the island."

For the installation of the 2,800 feet of ShoreGuard, a vibratory hammer was used. The hammer, which is connected to a backhoe or excavator, places the sheet and then vibrates it into place. "It is like a giant jackhammer," notes Berry, who adds the project took about two weeks to complete.

So for now, the Berry's island and the 800-square-foot ranch house that is Kevin's present home are safe from the effects of coastal erosion. With that problem solved, he is hoping to build a larger house on the island for his parents to use in their retirement.

Shoring Up a Village

In addition to supplying product for the island project, CMI has supplied its ShoreGuard products for a number of high-profile projects around the country, including a multi-million-dollar revitalization of the waterfront in East Rockaway, NY. The village of East Rockaway, in Nassau County on Long Island, is a bedroom community for New York City, which is less than 25 miles away. This multiphased project in the community of 10,000 people was designed to bring life back to the village's waterfront and includes restaurants, retail shops, galleries, and recreational facilities.

Several wooden bulkheads had been built along the waterfront since the community was established in the 1600s, and for the most part, these bulkheads had prevented erosion caused by wave action from boats from becoming a serious problem. However, with marine worms eating the existing bulkhead, something had to be done. There were concerns that if a section of the bulkhead that backed onto the street was compromised, sink holes and other problems would occur, so a major part of the restoration project was to replace the wooden bulkheads with a reliable, long-term solution. “With a maximum 10- to 15-year life expectancy, wood was not a viable option,” explains Dennis McCabe, superintendent of buildings and construction for the Village of East Rockaway. “We chose ShoreGuard vinyl sheets because we can expect a minimum 50-year life expectancy.”

For the East Rockaway project, ShoreGuard 550 was specified. The 550 product is Z-shaped and is manufactured in 12-inch panels that range in length from 14 to 26 feet. Two of the panels are put together in a pair, meaning 24 inches of the ShoreGuard product is installed at one time. The panels are connected using an interlocking system. To install the 1,800 feet of ShoreGuard 550 at the East Rockaway site, it took the installation contractor, Atlantic Coast Dock Building from West Islip, NY, approximately two to three months. A vibratory hammer on a floating barge was used for the installation, which McCabe said went well despite snow and ice. “We were still able to install the piling despite discovering several old submerged bulkheads, and inclement weather.”

Building Up Sand

Across the Atlantic Ocean on the southwest tip of Sweden, the City of Malmö is using what would definitely be considered a “soft” approach to tackling coastal erosion at the area’s popular Ribersborg Beach. The beach faces Oresund, which is a fairly narrow part of the Baltic Sea that separates Sweden from Denmark. In the past, workers from the City of Malmö had been going out to sea’s edge every year to retrieve sand with a tractor. This sand was then used to build the beach back up after winter storms had depleted the area’s sandy beaches. After more than 30 years of using this method, the city was looking for a new way to control erosion and decided to test an innovative method of protection offered by Naples, FL–based EcoShore International. The EcoShore system uses pressure-equalizing modules (PEMs) to control beach and coastal erosion. EcoShore’s system had not been used on any North American sites, but was introduced to the US market in 2004 and is patented in the US. To date, the system has been used successfully at a number of sites in Denmark, West Africa, and Asia.

“We had some environmental concerns about continuing to use the tractors as we did not want any oil leakage at the beach, and from a cost perspective, the old method was expensive and time-consuming,” explains Arne Mattsson, deputy head of the division that is responsible for the operation and maintenance of streets and parks for Malmö. “The inventors of the PEM system had heard about our problem and offered us a trial of their system, which was initiated in the fall of 2001.”

Photo: EcoShore International

Ribersborg Beach in October 2002 several months after PEM installation.

According to EcoShore International, PEMs are independent permeable drain tubes that are installed vertically into the beach, causing the beach to build up in both height and width. A wide and elevated beach generally offers the best protection against dune and bluff erosion. With the tubes inserted into the foreshore, the various layers of groundwater are connected, which creates a reduction of groundwater pressure, which in turn reduces pore pressure and increases intergranual friction—a process that makes the sand grains less likely to be washed back into the sea. When the waves leave more sand on the beach than they take back into the water, the beach eventually builds up. A telltale sign of a beach that has PEMs installed is the presence of a convex surf zone rather than a concave one, as much of the sand will be deposited near the water line.

The PEMs measure 2.5 inches in diameter and 6 feet in length, and form a grid pattern on the beach that stretches from the dunes into the water. A typical installation includes 70 to 100 PEMs per mile of beach, with each module positioned 1 foot below the surface. The prime conditions for PEMs to be successful include good circulation in the swash zone and sediment available in the littoral drift or system. The sand might be offshore sand that moves inward or passes by parallel to the beach. The effectiveness of the system is enhanced by tide and storm action, whereas with most other methods of coastal protection, these natural elements can have the opposite effect.

From an environmental perspective, PEM systems are popular because they are installed with the use of light equipment, require no power to operate, do not affect or harm marine life or wildlife, and are easily removed. They are placed below the surface of the beach, making them invisible.

PEMs are not new to Scandinavia; they were invented in Denmark in the early 1990s in the town of Skagen, which is located at the tip of Jutland. With a total shoreline of 4,500 miles (7,000 kilometers), Denmark had a number of eroding beaches, so a project group was formed to clarify the effects of PEM systems. The project committee was chaired by Dr. Hans F. Burcharth, who was editor-in-chief of Coastal Engineering Journal and editor of the US Army Corps of Engineers Shore Protection Manual.

The heavily eroded west coast of Jutland was selected as a test site, and the beach was monitored for three years, both with and without PEMs. The total length from the first flank to the end of the last control area was 5 miles (8 kilometers); however, the total measured length was half that because areas were left in between the measured areas so that data could be collected from a larger overall area. After 12 months, stretches of beach with the PEMs averaged gains of 8.4 cubic yards of sand per yard (with triple those gains in the middle of the test strip), while areas not equipped with PEMs lost from 1 to 22 cubic yards of sand per yard. This picture remained unchanged during the three-year test period, and after five years, the beach with PEMs was 2 feet higher than the control areas without PEMs.

Photo: Mandalay Wildlife Refuge

Sheet piling walls placed 5 feet apart.

The first step in an EcoShore installation is an initial evaluation by EcoShore International, which is free of charge. If this initial evaluation concludes that the potential client's expectations are matched against the expected performance of the PEM system, then a "coastal investigation" is offered. This comprehensive trial is done in cooperation with a consulting engineer, and includes data collection and analysis of coastal processes; beach and offshore profiles; sediment sampling and analysis; design analysis; coastal systems assessment; permit drawings; permitting procedure; construction and verification; aerial photos; measurement of the beach, sea floor, and flanks; installation of PEMs in a grid; adjustment of PEM installation if necessary; beach measurements three times per year; final measurements of the beach, sea floor and flanks; and a written report. Typically, results are seen within six to nine months of the initial installation, so after one year of the PEMs being installed, the client has the option to enter a lease agreement with EcoShore International. If the result of the coastal investigation is not satisfactory to both parties, then the PEM system is removed free of charge with no further obligation on the part of the client. If the results are successful and a lease agreement is initiated, the cost depends on a number of factors, including the number of PEMs used, the length of the contract period, the size of the beach or area that needs to be protected, and the type of contract.

"We really didn't have much to lose," says Malmö's Mattsson. "We had looked at other systems in the past, but we felt they were too expensive. With the PEM system we thought it was well worth trying for a year, especially with their commitment to remove the system if we were not happy with the results, and because it sounded so easy. After the first year we were very happy with the changes we were seeing as the beach was 4 to 5 meters wider, so we signed a three-year agreement, and we are now in the second year of that contract. On an annual basis, our own staff from the City of Malmö measures the beach, and we are happy to say we are gaining more sand every year."

Comparing Methods

At the Mandalay Wildlife Refuge near Houma, LA, 60 miles southwest of New Orleans, the US Fish and Wildlife Service (USFWS) has teamed up with the Louisiana Department of Natural Resources (LDNR) to test four different methods of preventing coastal erosion. The 4,212-acre refuge is bisected by the Gulf Intracoastal Waterway (GIWW), which stretches 1,109 miles from Apalachee Bay, FL, to Brownsville, TX, and handles almost as much cargo as the Panama Canal.

"A portion of the GIWW goes through Louisiana, and it cuts through our wetland habitat, including the Mandalay Wildlife Refuge, which is made up mostly of clay and organic soils," explains Mitch Andrus, P.E., an engineer with the LDNR Coastal Engineering Division in Baton Rouge, LA. "This waterway was built for navigation and, over the years, the canal has widened by three to four times the original width, primarily because of wave action from passing ships. We wanted to stop this erosion, but traditional methods such as rock dikes were not suitable because of the soil types, so we needed to come up with a lighter weight method of erosion control."

Photo: Mandalay Wildlife Refuge

Timber fencing units were built onsite.

Under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), a test project with a budget of $1.19 million was approved for engineering and design in 2000, with construction actually getting underway in October 2001. Construction was completed two years later, in September 2003, and the five-year research project is now in its second year. The mandate of the project was to develop new techniques for protecting and restoring the easily erodable organic soils.

With the project approval in hand, the LDNR and the USFWS went to Shaw Coastal Inc., an engineering consulting firm in Houma, where engineer Jeffery Peña got involved with the job. "Through the general engineering and surveying contract Shaw Coastal has with the LDNR, they hired us to do the engineering and design on the Mandalay project," notes Peña.

With cooperation among all of the partners, four different methods of erosion control were selected, and each method was tried in three different locations within the Mandalay Wildlife Refuge. Also included in the project are what Peña calls “control sites,” which are areas where no treatments were used. “These control sites are a benchmark for us, or a reference point, so that we can see what changes have happened with erosion control versus what would have happened if we had not done anything.”

The four methods of erosion control chosen were off-bank concrete armor units, straight-walled fiberglass sheet pile systems, revetment mats, and treated wooden fencing. Approximately 300 feet of each method were used at each site for a total of close to 1,000 feet of each method when all three sites were considered. All of the installations were completed by the Bertucci Contracting Corp. from Jefferson, LA.

The 24-foot concrete armor units, called A-Jacks, were supplied by Armortec Concrete Erosion Control Systems. The units were to be realigned from the bank’s edge because of the existing water depths, and to maintain the required water depth for the placement of the units. A geogrid was placed and pinned first, and then the A-Jacks were placed onto the geogrid with a specially equipped excavator. Initially, the crews had difficulty with the A-Jacks settling and parting from their intended set-up, but after some trials, they were able to place the units with very little settling and parting occurring.

The straight-walled fiberglass sheet piling, supplied by Lee Composites in Spring, TX, was driven in with a special flat-head hydraulic vibrator. Two sheet-wall sections were actually placed parallel to each other at a distance of 5 feet, and the space between the two walls was filled with a clay-type material that was dredged from the GIWW. The only major problems crews encountered with the sheet pile product were logs and root structures that prevented the sheet pile from being driven in far enough and, at one of the three sites, a stiff clay material that allowed the 20-foot sheets to be driven only 3 to 5 feet into the ground. For the clay sites, a special steel cap was made for the sheet pile, which allowed for an additional 5 to 6 feet of product to be driven into the ground. In some cases where the crews met heavy resistance from the ground, 10-foot sheets were used instead of the 20-foot sheets.

The concrete revetment mats, supplied by Houma-based Submar Inc., were installed with a crane and placed on top of fabric and a series of three 18-inch polyethylene pipes that were strapped together into a triangular shape. The finished product acted like a dike, but instead of a rock center, the lighter pipe reduced the possibility of the mats sinking. Anchors and straps were also installed per the manufacturer’s specifications. The moveable and reusable Submar mats, which measure 8 by 20 feet and are 4.5 inches thick, are laid across the pipes, making a raised section in the center.

The fencing, which was a treated product, was the least difficult of all four products to install, as the materials were transported by barge to each location and the crew then fabricated the sections to be installed. An excavator barge was used to set each section of wooden fence in place and to drive the fencing down to grade.

Peña says overall the installation went very smoothly, and the project in general is proceeding very well. “We really have to wait until the five-year study is completed before we can make any conclusions, but the installation went relatively well, and to date we have not had any problems with any of the test sites.”

Paul Yakupzack, the refuge manager, is also pleased with the project to date. “We have a number of wading birds, ducks, migratory birds, herons, egrets, marine life, and alligators, and the test sites do not have any effect on this wildlife,” explains Yakupzack, who is also a fish and wildlife biologist. “We quite often have gulls and terns sitting on the structures when they are exposed, and alligators sunning themselves on the Submar structures.”

There are numerous other solutions to coastal erosion, including concrete seawalls, groins, jetties, dikes, breakwaters, geotextile tubes, beach nourishment initiatives, and revegetation projects, but as with most types of erosion problems, there is not a “one product fits all” solution. As in the case of the Mandalay Wildlife Refuge and the private island off the coast of Texas, it takes trial and error, experimentation, and testing of different methods to come up with the right solution for each case.

Topics:

- Shoreline Protection,
- Streambank Repair,
- Channel Armoring