EROSION CONTROL

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Shoreline Protection Techniques

Combining technologies to stop ocean, lakefront, and channel erosion.

By Bill Tice

With the Caribbean Islands, the southeastern United States, and the Gulf of Mexico region facing some of the worst storms in years this past fall, including Hurricane Frances in August and Hurricane Ivan in September, images of damage to the environment from natural causes dominated television news coverage and the front pages of newspapers for weeks. But for many coastal communities, there is another natural event that causes extreme damage to the landscape. It is known as shoreline erosion, and although it doesn't have the same newsworthiness of a Class 5 hurricane, it is an ongoing problem that slowly forces shorelines and beaches to retreat, consuming valuable property in the process.

Solutions for a Florida Resort

Photo: International Erosion Conrtrol Systems

At Sand Hill Park on the Canadian side of Lake Erie, approximately 120 concrete mattresses 4 feet by 16 feet were installed to secure 400 feet of beach.

It's a problem Dan Nolan knows only too well. Nolan is the project manager for all construction, buildings, and beach work maintenance at the Amelia Company and its Amelia Island Plantation Resort, a family-oriented resort destination on Amelia Island, just northeast of Jacksonville, FL. The resort offers conference facilities along with golf and water activities, and has a hotel, townhouses, condominiums, and single-family homes.

"We actually began work on shoreline protection in 1991 when we started to experience problems due to severe nor'easters and subtropical-type storms," Nolan explains. "We did experience the outer bands of Hurricane Frances, and we had lots of flooding and tree damage, but very little shoreline erosion. That is not the case, however, during the nor'easter season when our beach erosion is much more extreme."

Nor'easters, also commonly called northeasters, are frequent in areas of the Eastern Seaboard where the Gulf Stream is present during the winter months. The nor'easters are so common that the Dolan-Davis Nor'easter Intensity Scale was developed to rate the strength of the storms. In a Class 1 nor'easter, the weakest level, beach erosion is limited to "minor changes"; however, a Class 5 nor'easter, the highest level, can cause "extreme beach erosion."

The higher-level storms, which are named for the winds that blow in from the northeast, produce heavy amounts of precipitation and create hurricane-force winds, resulting in high surfs that cause the severe beach erosion and coastal flooding. The greater frequency of nor'easters that Nolan neports for Amelia Island in the early 1990s is consistent with the findings of scientists and researchers who report that, between 1987 and 1993, at least one Class 4 or Class 5 storm occurred each year along the Atlantic Seaboard, which is a scenario that has only occurred once in the last 50 years.

When the problem reached epidemic proportions for Nolan's company, Amelia Island property owners and residents came together to form a self-taxing district in order to fund beach-renourishment and maintenance programs that could deal with emergency situations that occur as a result of the nor'easters, tropical storms, and hurricanes. With the programs in place, Nolan says the district has effectively used a number of techniques to stop shoreline and beach erosion, including geotextile tubes, scour aprons, groins, and a breakwater made from large rocks. Where possible, the solutions were done in conjunction with the planting of native vegetation. Some of the measures were temporary; others are permanent.

"Everything we have done has been broken down into different categories of work," Nolan notes. "One of the primary projects included pumping over 2 million cubic yards of sand from an offshore borrow site that is close to the island. We installed large

geotextile tubes or bags from Bradley Industrial Textiles in Valparaiso, FL, which were filled with a sand and water slurry, and then placed at the point where we lost primary and secondary dunes to shoreline erosion."

Most of the bags, which were between 55 and 100 feet in length and up to 30 feet in diameter, were placed parallel to the shore and replicated the effect of the dunes. "If you can visualize a dune, which is a land work of the ocean, it usually represents a natural break. But with the dunes being lost, we had to find another way to make that break," Nolan says. "This was essential, as we had already lost a large portion of our golf course and landscape, and we could have experienced a large loss of buildings, as the erosion had got to the point where it was right up to the foundation of some of our condominiums."

Photo: DH&JA Seeding

A coir log base with a wire turf reinforcement mat protects a slope.

A mat system, which Nolan calls a scour apron, was manufactured from the same geotextile material as the tubes. This was laid down first, and then held in place with an anchor system that was also manufactured from the same material as the geotextile tubes. The material used for the anchors was made into pockets that were 18 to 24 inches in width and filled with the slurry before the ends were sealed off and the anchoring system was laid down on both sides of the scour apron. The larger tubes were also filled with the slurry and placed on top. In total, the larger tubes covered more than 1,500 linear feet. "The bulk of these slurry-filled bags are still in place, but we did have to remove some for environmental permitting requirements," Nolan adds. "We covered the bags that remained with sand and planted sea oats and other natural beach vegetation that is [native] to the area, letting it grow and return the area to a more natural state."

Photo: Lake Rip Rap Inc.

By working from the water, crews can avoid disturbing sensitive shoreline habitat.

In addition to placing the filled bags parallel to the beach, some were positioned perpendicular to the beach and extending into the water and forming a temporary groin system. This system captures sand moving laterally from north to south, and helped lessen the erosion problem at the south end of the island. "This worked extremely well for us, but we had some follow up nor'easters that were really strong, and they took out a large number of the groins, so we removed the rest of them," Nolan says. "Because of the success we had, the property owners lobbied the state and federal governments to allow us to build a permanent groin and breakwater from large rocks, which we are in the process of doing right now."

After the permanent system is completed, Nolan expects the geotextile sandbags and tubes will be used only for emergency situations. "With the dynamics of the island, the wave damage comes in form the northeast and starts cutting the sand away to the south, which is a state park and a protected area. The permanent groin, which extends seaward for more than 1,100 feet, and the breakwater, which is 300 feet in length and sits approximately 100 yards offshore, will break up the turbulence caused by the waves. During low tide, sand will be captured and then start to move north, while at high tide, the sand will go over the breakwater and groin as it would in a natural setting."

As for the geotextile tubes, or sandbags, Nolan says that, under state law, they can only be used on a temporary basis. "They will not give us a permit to make them a permanent structure, which means we could be required to remove them at any time. However, also under Florida law, once you are approved for a beach renourishment program, you must continue the program as long as you are here. It's something we would do anyway in order to protect life and property, so we were happy to get the approval to install the permanent solutions."

Ship Channel Erosion

In Corpus Christi, TX, a marine terminal also has been dealing with shoreline erosion for a number of years. The terminal, which is on the Corpus Christi Ship Channel, unloads crude-oil vessels, and then ships the crude to refineries, where it is used as feed stock.

Over the past 20 years, a number of different shoreline-protection projects have taken place at the terminal, including the most recent project, which was handled as a turnkey operation by Submar Inc. of Houma, LA.

The terminal had been losing ground every year to shoreline erosion, and in the last three years had lost 60 feet of shoreline. Because of its location at the headwaters of the Corpus Christi Ship Channel, every vessel that comes into Corpus Christi has to go past the facility. With the average tanker carrying 800,000 barrels of crude oil at 432 pounds per barrel, that adds up to almost 175,000 tons. Add that to the average weight of the ship at 180,000 tons and there is a lot of water to displace. That water has to go out to fill the void, and then comes rushing back in, taking the shoreline with it.

Photo: Koch Pipeline Company

Articulated concrete revetment mats stopped erosion along the Corpus Christi Ship Channel in Texas.

Submar provided 800 feet of shoreline protection, providing both the materials and the labor for the project. The product used was Submar's 4.5-inch revetment mats, articulating concrete mats with a low hydraulic profile. The mats measure 8 by 20 feet and are 4.5 inches thick, each weighing 6,200 pounds. Each has open areas that allow vegetation to grow through the mats, helping to create wildlife habitat and increased diversity in the areas where they are installed. Submar completed about 300 feet several years ago and finished the last 500 feet in early 2004, which took about seven days to install. They brought the mats in on trucks and then used heavy equipment to lay them in place. The mats extend from the top of the bank into the water, and the area has been seeded with native plants.

Saving a Campground Beach

Photo: International Erosion Control Systems

Concrete mattresses helped stabilize the shoreline at Sand Hill Park along Lake Erie.

Shoreline erosion is not limited to oceanfront property, as John Alton can attest. Alton operates Sand Hill Park, a privately owned campground on the Canadian side of Lake Erie. "We were experiencing very high water levels this year [2004] and Lake Erie was 2 feet higher than it was in previous years," explains Alton, who is the fifth-generation member of his family to operate the 300-site campground; it was started in 1854 by his great-great-grandfather.

The park, which is located in southern Ontario and between Detroit to the west and Buffalo, NY, to the east, is experiencing erosion at the toe of its 120-foot-high bluff due to the higher water levels. "With the water right up against the bank, it was creating a very steep and unstable cliff, so for the safety of our campers, and to protect the shoreline, we realized that we had to do something," Alton says.

In the past, Alton says, he had used large rocks to stabilize the shoreline. However this solution restricted access to the beach, so he was looking for an alternative. "We wanted something that would maintain our access to the water, and I had been aware of cable concrete block mattress systems from International Erosion Control [IEC] in West Lorne, Ontario, for some time. They are designed to protect banks from erosion, so we decided to give them a try."

The IEC product, which Alton describes as "looking like giant ice-cube trays," is made from individual concrete blocks fastened together with stainless steel cable. For the Sand Hill project, two layers of fabric were placed underneath the mattresses to ensure there were no spaces. The concrete mattresses hold the sand and fabric in place. Each 4-foot-wide by 16-foot-long mattress was positioned vertically along the bank. Approximately half of the 16-foot length was positioned in the water, leaving about 8 feet of the mattress was above the water line. Another row of mattresses was placed horizontally on top to form a cap. In total, Alton says, it took approximately 120 of the mattresses to secure 400 feet of beach.

"The whole job took about two weeks to complete," he notes. "We had some rough weather to start with, which slowed us down, but once we got going it didn't take that long. Because we didn't have a lot of room to work with on the beach, we stockpiled the mattresses elsewhere and then brought them down to the beach with a rubber tire front-end loader. We then used an excavator

to lower them into position. We are very happy with the results, and our customers that were here before we did the project were amazed when they came back a few months later and we had a dry walkway where they had been walking in water before."

Working From the Water

Hank Sutton is passionate about shoreline protection. The retired Illinois Department of Transportation [DOT] employee, who lives 30 miles south of Springfield, IL, on Sunset Lake, owns Lake Rip Rap Inc. with his wife, Karen. "I fell into this quite accidentally," Sutton explains. "I have lived on the water since I was a kid, and in the mid 1980s we were looking at the possibility of dredging Sunset Lake due to all the sediment that had collected in the coves. With my background with the Illinois DOT, I was familiar with dredging sand, but not sediment, so to learn about dredging sediment, I joined the Illinois Lake Management Association [ILMA], which at the time was a new organization. From my involvement with the ILMA, I quickly saw a big need for shoreline erosion control that wouldn't damage the environment, which meant using boats and doing the work from the water. I did a lot of investigating, developed a passion for it, and then designed a boat for doing the work. In 1994, my son was starting college, so I built a small boat for him to run in the summer so that he could finance his education, and that was basically the start of the business."

Sutton was still working for the Illinois DOT while his son was at college, but retired around the same time his son graduated. "It was 1998 when I retired and my son went on to other things, so I made some improvements on the boat, enlarged it, and continued on with the business. In 2001, we built a bigger boat, and then this year, we added a third boat. I just keep reading about shoreline erosion, and researching the subject, and the business keeps growing."

The first boat built by Sutton, which is called the Lake Rip Rap Model 310, is transportable without disassembly, has an overall length of 52 feet, and drafts 24 inches. With a payload of 14 tons, the 310 can place 12,000 tons of bulk materials per year. Sutton's second boat was a larger Model 415b, which is also transportable but with the front conveyor removed. The overall length is 82 feet, and it weighs 34 tons empty and 54 tons loaded, which gives a loaded draft of 33 inches. With a payload of 20 tons, the 415b can place 30,000 tons of bulk material annually. The third boat, the Model 410, was built last winter and is lighter, faster, less complicated, and easier to transport than the 415b. The center of gravity was moved back, which raised the bow to allow for a shorter, lighter conveyor, and the boat is18 inches wider. The loaded center of gravity can be varied 30 inches fore to aft by payload placement, which accommodates varying shoreline topography. The overall length is 64 feet and it weighs in at 23 tons empty and 43 tons loaded, resulting in a variable bow draft of 24 to 33 inches and a variable stern draft of 27 to 36 inches. The Model 410 also has a payload of 20 tons and is a little faster than the 415.

Sutton says by operating from the water, workers do not have to disturb any of the natural forest or shoreline. "We don't want to damage the environment in any way, so working from the water is the best way for us to go. We also have the capability of hydroseeding when the bank behind the riprap reaches a stable slope."

Sutton uses a combination of hard-armor techniques, such as riprap, in conjunction with soft-armor techniques such as substrate modification, turf reinforcement mats, and transitional wetlands. "The primary goal of any project for us is stopping the retreat of the shoreline, followed closely by developing a habitat," Sutton notes. "I am sensitive to providing shoreline habitat wherever we can, and this is an area where we have recently made a lot of progress. In many of the reservoirs we work on, we encounter a situation where the topsoil is gone and we are into sterile subsoil, which is lacking in nutrients, microbes, and organic material required by plants. As soon as this material softens under water, the wave energy takes it out. So the first thing you have to do in order to provide a shoreline habitat is stabilize the shoreline, and the second thing is to bring in good soil that is conducive to plant growth. We have done a lot of this work by building breakwaters with riprap to establish an area of protected wetland habitat, and we have built structural revetments just above the water level, also with riprap. We inject select topsoil into the voids, which is encapsulated by an internal fabric wave barrier. We then seed with native, non-aggressive species and let nature take its course."

Photo: DH&JA Seeding

A gabion face and turf reinforcement mat on the top slope help reinforce the channel.

Another area Sutton has researched extensively is lean or "light" installation. "This is a process where we don't skimp on the substrate filter, but we lighten up on the riprap," explains Sutton, who says it's usually done on steeper slopes. "When using this technique, we expect some localized failures, but the tradeoff is a large quantity reduction in materials. We do not expect a zero-failure rate. If we don't have any failures, then we are probably overbuilding. These localized failures are easily repaired and fortified if necessary. Where you have a valuable structure to protect, you can go with a more substantial design in that area."

Sutton notes that this lighter approach, along with soft-armor techniques, is becoming more popular with his clients, mainly local governments. "The more educated people get, the more popular these techniques are becoming. These methods are less expensive as we are using far less material, and I have never seen a project where the budget was not a major concern."

High-Velocity Urban Channels

Donavan Hite also deals with shoreline erosion, but most of the projects he takes on involve protecting urban creek shorelines. Hite is one of the owners of DH&JA Seeding, located in the landlocked state of Missouri. "Because we are not on an ocean or one of the Great Lakes, we are handling much smaller projects. However, we are dealing with higher velocities," Hite notes.

DH&JA, which was started approximately three years ago and now has five employees, specializes in creek stabilization and wetlands restoration, areas Hite worked in for 10 years before the startup of his Kansas City-area company. Most of the work his company does involves a combination of hard-armor and soft-armor techniques. In most cases the company doesn't do its own specifications but follows the plans draws up by landscape engineers for the individual projects. "Most of the time the plan is drawn up prior to us walking onsite, but we are noticing more of a demand for soft armor. Depending on the velocity of the stream, we will quite often see concrete and riprap on hard corners, then we will pull out to coir logs and erosion control blankets on the straight runs of the channel."

Another solution Hite likes to see is the inclusion of root mass in the stabilization projects. "Creek channels and shorelines will always move and the engineers and the general public are starting to understand that concept, and are providing these waterways with more room to roam. Root mass will always do better than hard armor, because when you use hard-armor techniques, there is never enough money to chase a channel the entire way, so you end up with more velocity further downstream due to the accelerated velocity you have created through the hard armor. Upstream, you end up with water undercutting the hard armor, which will eventually cause the hard armor to fail. In my opinion, that is why hard armor has to be used sparingly, and when it is used, it has to be put in strategic places."

Hite points to a recent project on Rock Creek in Gladstone, MO, as an example of successfully using soft and hard armor techniques together. "For this project, we used wire turf reinforcement mats [TRMs], gabions, and coir logs," he explains. "The creek was in an urban corridor and had caused a lot of flooding in the past because it could not take the water from the surrounding impervious area. To correct the problem, the stream was widened, the steeper slopes were reinforced with gabion baskets, and the shoreline on the flatter slopes was protected with coir logs and wire TRMs."

The project, which was for the city of Gladstone, covered a half-mile of the creek and was completed at the end of July 2004. "Since the project was finished, we had one rainfall that dropped 6 inches of rain, and we have had four rainfalls that were 3 inches or more, and we have not had one failure."

As with most erosion control projects, shoreline protection can be achieved using a number of different products and techniques, alone or in combination. Whether it's protecting the shoreline and beach on an open ocean or maintaining the creek bank on an inland waterway, careful planning and selecting the right products can help erosion control professionals achieve successful results.

Topics:

- Shoreline Protection,
- Geosynthetics and RECPs,
- Project Design