Sea Grant New York

MAINTAINING SHORELINE EROSION CONTROL STRUCTURES

Figure 1. The ever-present energies of nature can quickly reduce human efforts to control shoreline erosion to picturesque, but useless, remnants.

Most people would never think of letting a car go without a tune-up or oil change. If they did, its life expectancy would be quite short. Unfortunately, many coastal property owners who have invested the price of a car (or more) into an erosion control structure frequently neglect to perform maintenance on that structure until it becomes so deteriorated that either its appearance or failure prompts them to take action (Fig. 1). In such cases, not only the structure itself is lost, but also the property that the structure was intended to protect. The ounce of prevention here is often worth far more than a pound of cure.

A landowner must make a judgment as to whether it is economically and physically feasible to repair a deteriorating structure or whether it might be more practical to replace the structure. There are two basic categories of erosion control structure deterioration: (1) aging, degradation, or damage to individual components that make up the structure, and (2) aging or damage to the structure as a whole. Material deterioration due to aging is more difficult to repair than is structural component damage on a new or well-maintained structure. A property owner should consult with a qualified marine engineer, contractor, or Sea Grant coastal erosion specialist before making a decision to repair or replace, and then make that determination based upon all the relevant facts.

General Maintenance Guidelines

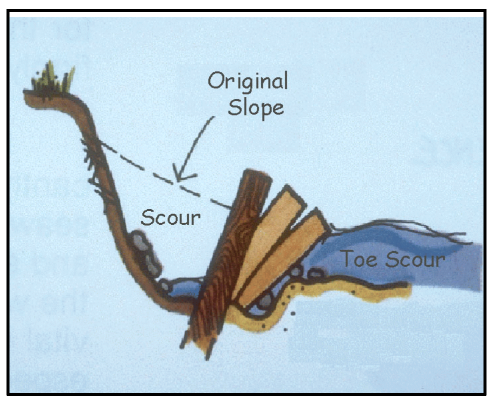

Figure 2. Loss of toe protection can result in a structure tipping toward the water

The first, and most basic, maintenance guideline for erosion control structures is to periodically inspect the structure for any visible signs of deterioration or failure. Try to remember what the structure looked like when it was new (owners of new structures should take photos of the structures for later reference). Are there visible changes? Look at the toe of the structure where it meets the water. Are there signs that wave energy is starting to undermine the structure? If you can't get a good look under the front edge of the structure, some telltale signs of toe failure are tilting, tipping (Fig. 2) or other movement of the structure toward the water, or uneven settling of some sections. If toe erosion is evident, but hasn't progressed too far, additional protection in front of the structure's toe should be considered. A greater amount of undermining might call for construction of a new foundation under or in front of the structure.

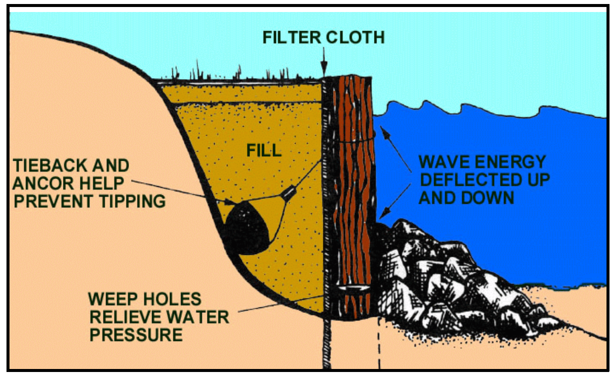

Figure 3. Filtration, toe protection, and tiebacks all contribute to a stable structure

Next, take a close look at the material of the structure itself. Is it cracking or separating? Are some areas settling more than others? Are there gaps, holes, or spaces that weren't there originally? Are spaces or hollows forming beneath or behind the structure? These are all signs that soil is being eroded from beneath or behind the structure, weakening the structure's protection of both itself and the land. First, the cause should be determined and corrected. Often, loss of fill takes place through holes, cracks or spaces in a structure or from beneath the structure because of a failure of the filtration material. New filter cloth or a bed of graded gravel should be placed where fill is leaking to hold back any further loss and allow water to drain out. Then the voids, hollows, or spaces should be refilled with clean fill. If you find that no filter material was ever placed behind the structure, it may be possible to excavate behind the structure (down to a foot or two below the level of the ground on the waterward side of the structure) and line the landward side with filter cloth or gravel, and then backfill with new fill material. Maintenance of tieback systems which help keep the structure vertical are also important (Fig. 3).

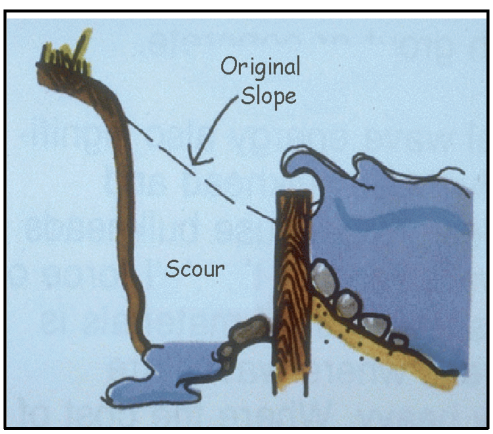

Figure 4. Wave overtopping can weaken an erosion control structure from behind

Look at the land immediately behind the structure. Are there voids or hollows forming (Fig. 4)? Is the ground always wet or littered with debris after a period of heavy waves? This is an indication that the structure is too low for the wave conditions and is being overtopped by incoming waves. White water or spray is acceptable, but "green water" over the top is a bad sign. In such cases an alternative is to add onto the structure to make it higher. If this is impractical, a splash apron (a less-permeable ground, usually large stones or concrete blocks, covering behind the top) could be installed to direct the water back into the lake or ocean and to prevent it from eroding soil from behind the structure.

Next, see if erosion is working its way around the ends of the structure, or "flanking" the structure (Fig. 5). Once erosion has started to flank an end of a structure, the integrity of the entire structure is jeopardized. If this is the case, the structure should be extended with new material at the ends and tied back into your land so that nature cannot get around it as easily. Soil already eroded away should be replaced with new fill.

More specific signs indicating deterioration and potential failure vary with the type of structure and are explained in more detail in what follows. Early detection and correction of these problems can significantly extend the useful life of your structure.

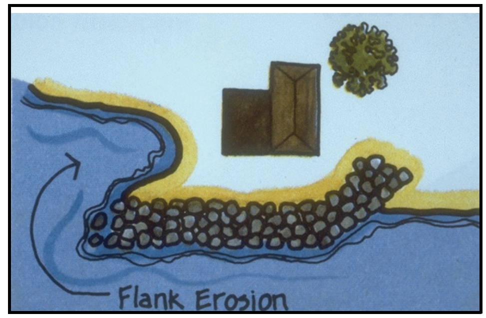

Figure 5.

Wooden Bulkheads

Properly designed, constructed, and maintained wooden bulkheads can provide effective protection for 10-20 years. When inspecting your bulkhead, sight along the top of the structure parallel to the shoreline. If the top appears wavy or bowed rather than straight, one or more of the tieback rods or deadmen that anchor the structure may be defective. To correct this, it is necessary to excavate behind the bulkhead and repair or replace the broken tieback. If excavation is not possible, bracing along the front of the wall with "batter" piles (piles driven into the ground at an angle and attached to the vertical wall piles) may be suitable in some cases (Fig. 6). In some situations, armor stone in front of the wall can be used to provide support and extend the life of the structure.

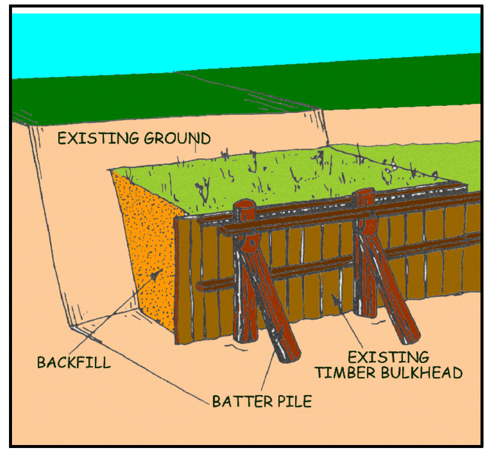

Figure 6. Batter piles can shore up a deteriorating bulkhead

Next, sight along the bottom of the structure. Boards that are misaligned or angled seaward at the base indicate undercutting due to toe scour. The boards should be realigned to a vertical position. Fill and additional toe protection such as large stones or a vertical sheet-pile cutoff wall (a low wall of tongue-and-groove boards carefully driven or jetted into the ground) should be placed in front of the structure (Fig. 7). In general, if you find that the toe of a structure doesn't extend below the ground level at least the equivalent of the height of the largest unbroken wave which may be expected to occur in front of the structure, a cutoff wall or some armor stone should be installed in front of the toe to prevent undermining. Loss of soil from behind the structure can lead to lack of support and collapse during storms. Soil can leak through holes caused by missing or damaged boards and through cracks and seams that widen as an aging structure settles. Small holes in the bulkhead should be repaired by screwing, nailing or bolting treated wood sheets or planks to the face of the structure to prevent further loss of fill. Filter material should be included as discussed earlier.

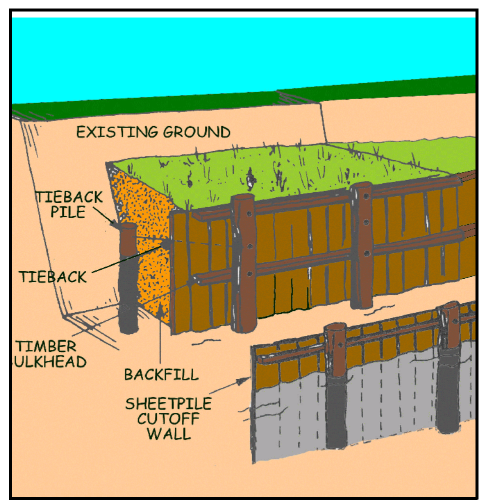

Figure 7. A cutoff wall driven ahead of a bulkhead can help protect the toe of the wall

Wood in the marine environment is susceptible to attack by a variety of organisms. Fungi cause rot above the waterline; below, marine borers burrow into the wood, reducing its strength. Only wood that has been commercially pressure treated with the appropriate preservative should be used in marine construction. A number of wood preservatives are available. A recent study by the New York State Department of Environmental Conservation[1] found that using wood properly treated with CCA (chromated copper arsenate) or creosote is not likely to have a significant impact on aquatic life but wood treated with pentachlorophenal should not be used in salt water. Untreated wood, in which marine borer larvae may grow, should never be used adjacent to treated wood.

As part of a maintenance program, untreated wood exposed by cutting or drilling should be treated with preservatives. Bolt holes should be flooded with preservative and capped with a treated wood plug. Ends of cut lumber should be soaked or brushed. Application should be continued until the wood no longer absorbs the preservative. Some wood preservatives are highly toxic; follow manufacturers' directions closely. After treatment, pile ends should be capped with a waterproof material such as epoxy or fiberglass.

Above the waterline, mushroom like encrustations, a softening or discoloration of the wood, or a fluffy or cottony appearance indicates advanced rot. Areas such as bolt holes or cut ends of lumber where untreated wood has been exposed to moisture should be inspected. Since most rot occurs beneath the surface and cannot be detected by visual inspection, the wood should be tested by sounding with a hammer. Infected wood produces a dull thud in contrast to the clear ring of solid wood. In suspicious-sounding areas, drill a small (3/8-inch diameter) hole. A sudden decrease in resistance to drilling and fine, moldy-smelling particles from the interior signal the presence of rot. Inspection holes should be plugged with treated dowels to prevent further damage.

At low tide, examine the portion of the structure beneath the high-tide mark for damage caused by marine borers. Gribbles, tiny, crablike animals that burrow just beneath the wood surface, cause a thinning of wood at the waterline producing an hourglass shape on piles. Shipworms leave little or no external evidence, but can cause severe structural damage by burrowing extensive tunnels in the wood's interior. To check for shipworms, tap the wood with a hammer. A hollow, drum like sound indicates their presence. If the bottom of your structure is always submerged, probe the wood beneath the water with a nail driven through the end of a stick. Feel for soft, spongy wood or voids.

Missing or damaged boards or piles can be replaced. However, this should be viewed as a temporary or stopgap measure, for the presence of borers in one section usually means the whole structure is infested. Although the attack may be stopped by armoring the structure with concrete or metal sheeting or using preservative or plastic wraps, this may be more costly and less effective than a new, treated-wood bulkhead. If you detect rot or marine borer damage, a qualified marine contractor should be consulted.

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1 *Assessment of the Risks to Aquatic Life from the Use of Pressure Treated Wood in Water,* NYSDEC Division of Fish Wildlife & Marine Resources, March 2000

Finally, all hardware and metal fasteners should be checked. Nails that aren't flush with the surface should be redriven. Loose bolts or fasteners should be tightened. Missing or corroded hardware should be replaced with corrosion-resistant hot-dipped galvanized steel or wrought iron. Dissimilar metals should not be in contact because this can increase the rate of corrosion in seawater. All washers should bear evenly on the timbers and should be large enough to prevent the bolt heads from pulling through the wood.

Gabions

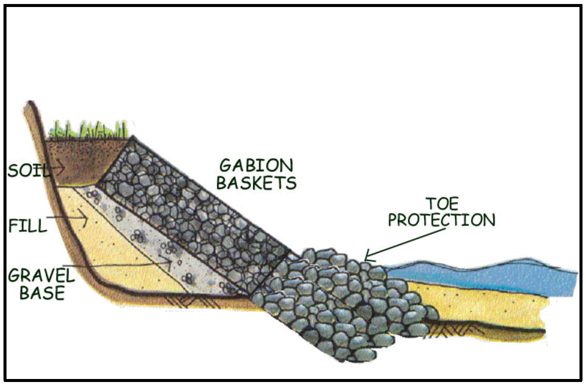

Figure 8. Toe protection should be placed ahead of, but not on top of, gabion baskets

Although gabions are flexible and can remain functional even if some settling occurs, it is still important to check their alignment. As with other structures, severe tilting or leaning usually indicates an unstable foundation or undermining by wave scour. In such cases it's important to realign the structure (if possible) and fill any voids at the base. It may be possible to place thin, wide gabion mattresses in the space under the realigned structure to provide a firm foundation and help protect against toe scour. Other remedial measures include filling the voids under the structure with rocks or gravel and then installing rock armor or a cutoff wall at the base to protect the toe (Fig. 8). Toe armor should never be placed directly on top the gabions as movement of the rocks can damage the wire and the weight of the armor could crush the baskets.

Figure 9. Gabion weakened by broken wires and spilled stones

Stones within gabion baskets may settle, leaving voids, decreasing structural strength, and allowing movement of the stone that can damage the mesh. Broken wires can also cause stones to spill (Fig. 9). If this occurs in a basket without other units stacked on top of it, open the basket, pack it tightly with 4- to 8-inch stones, and rewire the lid shut, taking care not to cut or damage the PVC coating if present (in salt water environments, polyvinyl chloride coating is used on the wires of gabions to protect them against corrosion). Adjacent gabions must remain tightly laced along the entire perimeter of all contact surfaces. The mesh and connecting wire should be inspected for signs of deterioration. Broken or corroded wires should be replaced with new galvanized (freshwater) or PVC-coated (saltwater) material.

Finally, check the mesh and wire for signs of abrasion. Waterborne sand, cobbles, or debris can wear away PVC and galvanized coating, resulting in increased corrosion and thinning of the wire. When scour is detected, the damaged wire should be replaced and the new wire protected by a rock blanket at the base, or a row of sacrificial gabions (which can be periodically replaced) along the front, or by grouting the lower part of the structure with asphalt or marine-grade concrete.

Stone Revetments

Although stone itself is extremely durable, stone revetments are nonetheless subject to a certain amount of deterioration as a result of direct wave action and erosion behind or beneath the stones.

Stone revetments should periodically be checked for settling or displacement of the individual stones that make up the structure. Occasionally, stones too light for the wave climate are used. In such a case stones may be moved by large waves, resulting in thinned portions of the structure that do not offer enough protection to the land behind it. This also weakens the rest of the structure and can lead to an overall failure. If an inspection reveals that stones have shifted or moved, new stone should be placed to fill the spaces created. You should consider the use of heavier stone when replacing the missing stones in order to provide greater protection against future movement.

Next, inspect the toe of the revetment. If not properly installed, a revetment can be undermined by wave action at the toe. This can be seen as a rapid settling of the stones at the base of the structure, or a displacement of stones allowing others above them to slide down toward the water. To correct this before the structure fails would require new stone placed in a trench dug at the toe and extending up beyond the bottom onto the face of the remaining original stones. An alternative could be a scour apron of large flat stones laid in front of the toe of the structure, rather than in a trench. Either of these measures would require the services of a professional marine contractor with heavy equipment, but would be less expensive than losing the entire original structure and the land behind it.

Figure 10. Uneven settling or displacement of revetment stones can be caused by a loss of fine materials as a result of poor filtration

It is possible that soil behind or beneath the revetment has been slowly eroded away by water that has washed over the stones or has run off the land behind the structure. Look for spaces or voids behind or beneath the stones. Check for uneven settling of stones in some areas of the revetment. This is commonly caused by a failure of the underlying filter material to prevent the soil under the structure from being washed out between the stones. Two alternatives present themselves: remove the stones in the affected area, install new filter material as described earlier, and replace the armor stone; or, place new armor stone on the surface over the settled stones. The former is more expensive, but may last longer, increase the structure's overall strength, and be more effective by preventing future loss of soil from behind the structure. The latter, though less costly, does nothing to eliminate the cause of the problem, but could extend the life of the structure for a shorter period of time. If there are voids or hollows forming just behind the top of the structure it is an indication that the structure is too low for the wave conditions and is being overtopped by incoming waves. In such cases the "best" alternative is to add onto the structure to make it higher. If this is impractical, a splash apron (a less-permeable ground, usually large stones or concrete blocks, covering behind the top) could be installed to direct the water back into the lake or ocean and to prevent it from eroding soil from behind the structure.

Concrete Bulkheads and Seawalls

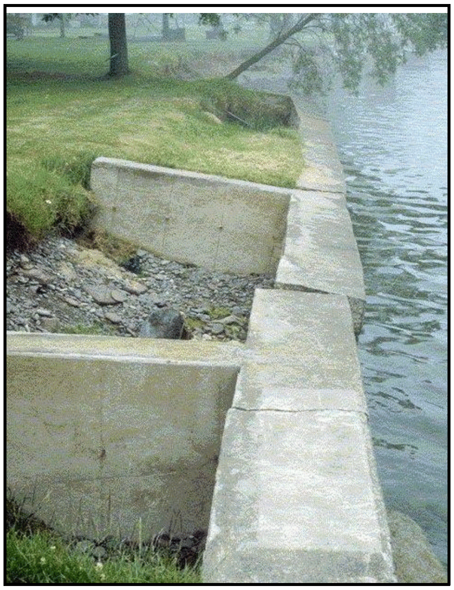

Figure 11. Lack of toe protection and poor tiebacks doomed this bulkhead to failure

First, check the vertical angle of the wall. Is it still upright or is it leaning toward the water? If the wall has tipped forward, either the toe has been undermined by wave attack or the support provided by the tieback/deadman system has failed (Fig. 11). To prevent total failure of the wall, it's important to reestablish a vertical alignment and anchor the wall firmly in place. If the toe was undermined, any voids should be filled, and additional toe protection (such as a row or two of heavy rock) should be installed.

Inspect the face of the wall. Is the concrete cracked, chipped, or split? In the winter, water can seep into these cracks, freeze and expand, and widen the openings. The problem can continue to get worse unless the cracks are filled with epoxy or patching concrete.

Major cracks in a concrete structure or a bowing-out of the wall may signal a drainage problem. Weep (or drainage) holes are important for relieving the pressure of water that can build up behind an impermeable concrete structure. These holes should be inspected to make sure they are not plugged up (or to make sure they were installed in the first place). If you can find what looks like a row of holes in the face of the wall above the waterline, watch them for a flow of water out of them during periods of heavy rainfall or snowmelt. If the wall is more than 20 years old, it's likely that sediment has built up and is blocking drainage holes. Weep holes should be cleaned out if they are not draining. If you can't find any weep holes, contact a contractor to see about having some installed (don't do this work yourself; improperly performed, drilling the wall could reduce its strength and lead to premature failure). Weep holes should always have filter material at their landward end to prevent soil from being lost through them (Fig. 12).

Figure 12. Poor drainage and poor filtration resulted in loss of fill from behind this bulkhead

Sand Fencing

On wide, sandy beaches, wooden or fabric fencing is used to encourage the deposition of windblown sand and to create new dunes. The most commonly used and easily obtainable material is slat snow fencing. Because of their fragile nature, sand fences require diligent maintenance.

The condition of the fencing should be inspected. Sections damaged by corrosion of the wire, deterioration of the wood, or vandalism should be replaced. For maximum sand-trapping efficiency, replacement fencing should have a ratio of open area to total area of about 50%. The width of the slats (and spaces between the slats) should be less than 2 inches. In replacing fence, posts should be driven at least 2 to 3 feet, and the slats should extend at least 2 to 3 inches into the sand. Anything less will allow a blowout to form under the fence, preventing a buildup of sand. Fencing knocked down by waves should be relocated far enough away from the water's edge to prevent further wave damage.

In areas with a large supply of sand, fencing may fill to capacity within a year. When sand reaches the top of the fence, additional fencing can be installed to continue the dune-building process. A higher, wider dune can be built by placing a fence two-thirds of the way up the sea ward slope of the dune created by the first fence. The base of the dune can be widened by placing a new fence or series of fences parallel to, and seaward of the first fence, provided this area is not subject to wave action. When using more than one row of fencing, place the rows four times the fence height apart to maximize sand-trapping efficiency.

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