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Maintaining Coastal Erosion Control Structures

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

Most people who own a car would never think of letting it go through its life without a tune-up or an oil change. In fact, if they did, its life would most likely be quite short. However, many coastal property owners who have invested the price of a car (or more) into a shoreline erosion control structure frequently neglect to perform any maintenance on that structure until it becomes so deteriorated that either its appearance or failure finally prompts them to take action. In these cases, not only the structure itself is threatened, but also the property that the structure was originally constructed to protect. The ounce of prevention here is often worth far more than a pound of cure.

There are two basic categories of erosion control structure deterioration: aging or damage to individual components that make up the structure (a degradation of the materials) and aging or damage to the structure as a whole. A landowner must make a judgment call as to whether it is economically and practically feasible to repair a deteriorating structure or whether it might be more practical to replace the structure. 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 specialist before making a decision to repair or replace, and then make that determination based upon all the relevent facts.

General Maintenance Guidelines

The first, and most basic, maintenance guideline for an erosion control structure is to periodically inspect your structure for any visible signs of deterioration or failure. Try to remember what the structure looked like when it was new. Has it changed much? Look at the toe of the structure where it meets the water. Is it being undermined? If you can't get a good look under the front edge of the stucture, some telltale signs of toe failure are movement of the structure toward the water, tilting or tipping, 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 (see fig. 2).

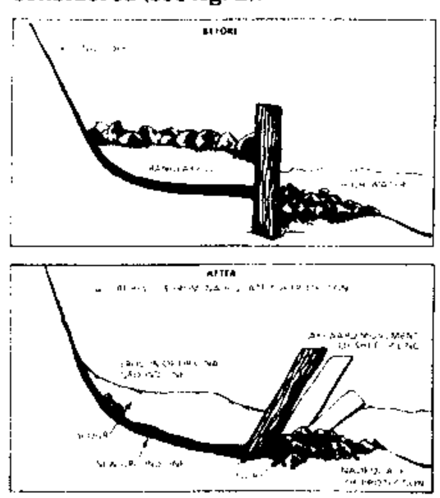
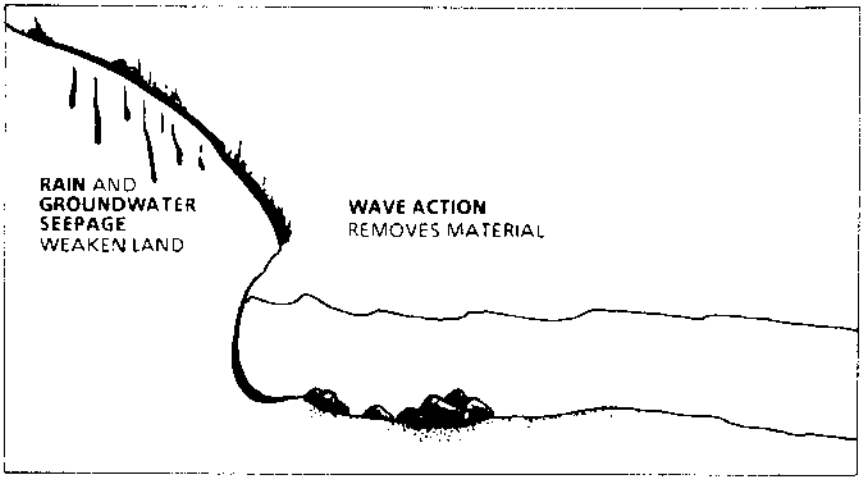


Figure 2. Protect the toe from undermining. (Figs. 2, 3, 5, and 6 are based on U.S. Army Corps of Engineers diagrams.)



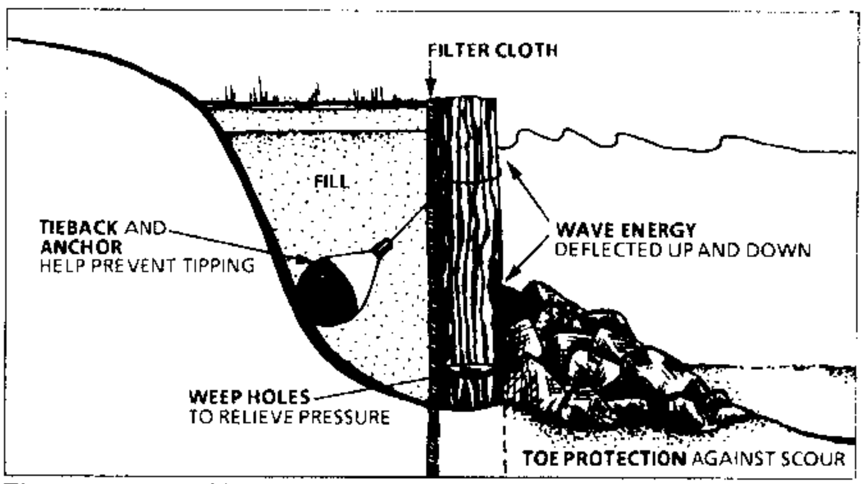


Figure 3. Proper filtration should be maintained.

Now 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 hollows forming under or behind the structure? These are all signs that soil is being eroded from beneath or through the structure, weakening its grip on both itself and your land. First, the cause should be determined and corrected. Often, loss of fill takes place through holes or spaces in a structure or underneath the structure because of a failure of the filtration material. New filter cloth or a bed of graded gravel should be placed where the 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 gravel. 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 (see fig. 3).

Look at the land just behind the top of the structure. Are there voids or hollows forming? 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 overtopping is acceptable, but "green water" or actual wave action over the top is a bad sign. In such cases the "best" alternative is to build onto the structure to make it higher. If this is impractical, a splash apron (a less-permeable ground 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 the ends of the structure are being "flanked," or eroded around. Once erosion has established a "beachhead" at one end, 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.

Wooden Bulkheads

Properly designed, constructed, and maintained wooden bulkheads can provide effective protection for 30-40 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 (see fig. 5). In some cases armor stone in front of the wall can be used to provide support and extend the life of the structure.

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 (see fig. 5). 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 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. Any holes in the bulkhead should be repaired by nailing treated wood sheets or planks to the face of the structure. This will prevent further loss of fill. Filter material should be included as discussed earlier.

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. Wood used in marine construction should be commercially pressure treated with CCA (chromated copper arsenate) or cresote to inhibit biological attack. These wood treatments are effective only on the larval forms of borers; adult borers can still attack treated wood. Therefore, untreated wood, in which marine borer larvae may grow, should never be used adjacent to treated wood.

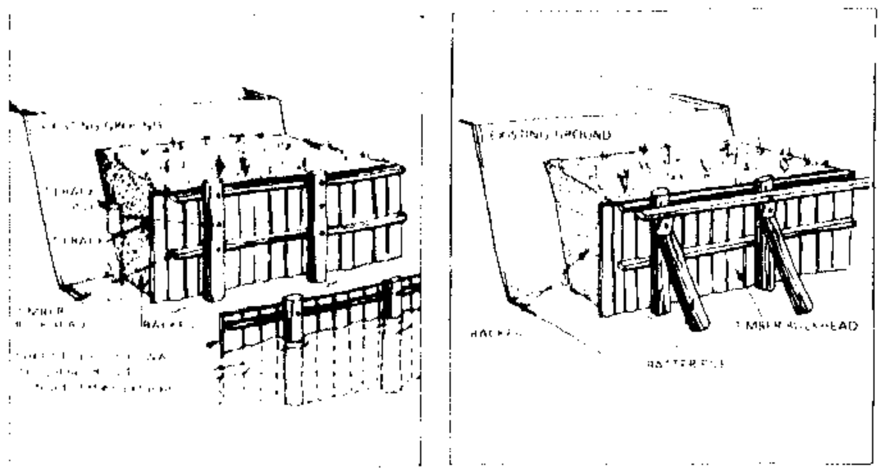


Figure 5. Cutoff walls and batter piles can help save a wooden bulkhead.

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. (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, mushroomlike 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

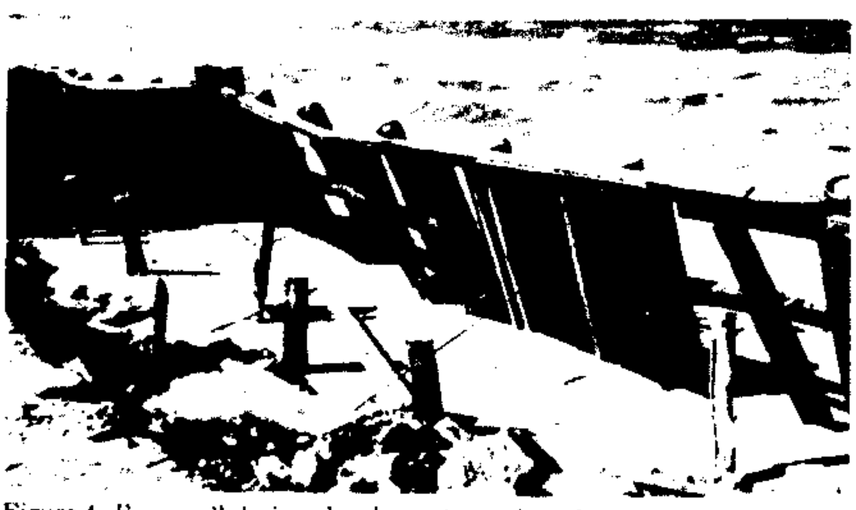


Figure 4. Even well designed and -constructed erosion control structures can fail if they are not continually maintained and repaired.

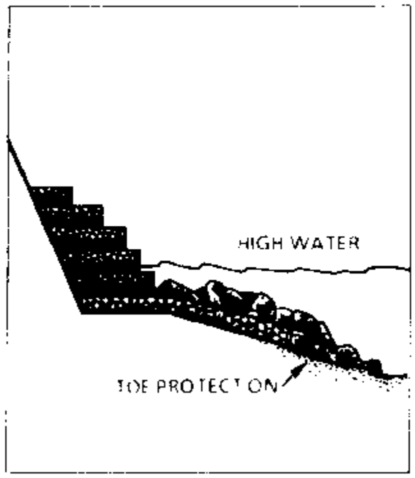
severe structural damage by burrowing extensive tunnels in the wood's interior. To check for shipworms, tap the wood with a hammer. A hollow, drumlike sound indicates their presence. If the bottom of your structure is always submerged, probe the wood beneath the water with a nail driven through the end 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.

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 boltheads from pulling through the wood.

Gabions

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 toe scour. In such cases it's important to realign the structure 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



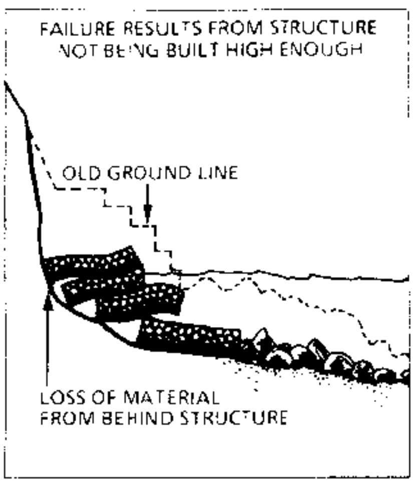


Figure 6. Waves breaking over a structure can lead to premature failure.

structure with sand or gravel and then installing rock armor or a cutoff wall at the base to protect the toe (see fig. 6).

In the marine environment, PVC (polyvinyl chloride) coating is used on the wires of gabions to protect them against corrosion. Stones within gabion baskets may settle, leaving voids, decreasing structural strength, and allowing movement of the stone that can damage the mesh. If this occurs, 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.

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 PVC-coated material.

Finally, check the mesh and wire for signs of abrasion. Waterborne sand, cobbles, or debris can wear away the PVC and galvanized coating, resulting in increased corrosion and a 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 be periodically 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 heavy waves, resulting in thin spots in the structure that do not offer enough protection to the land behind it. This also weakens the rest of the structure in that area and can lead to a failure of the structure. If an inspection reveals that stones have been shifted or moved, new material should be placed to fill in the spaces created. You should consider the use of heavier stone when replacing the missing stones in order to provide greater protection to the structure.

Next, inspect the toe of your revetment. If not properly installed, a revetment can be undermined by wave action at the toe. This can be seen as a "marching toward the sea," 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, usually starting in a trench dug at the toe and then extending up beyond the bottom and 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 probably require the services of a professional marine contractor with heavy equipment, but would still be less expensive than the alternative of losing the structure and the land behind it.

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 in the structure. Also check for any uneven settling of stones in some areas of the revetment. This is commonly caused by a failure of the filter material behind the revetment to prevent the soil under the structure from being washed out between the stones. Two alternatives present themselves here: remove the stones in the affected area, install new filter material as described earlier, and replace the armor stone; or place new armor stones 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. The latter, though less costly, does nothing to eliminate the cause of the problem, but could extend the life of the structure, though not for as long as the replacement of filter material could.

Concrete Bulkheads and Seawalls

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. To prevent total failure of the wall, it's important to reestablish the wall in a vertical position and anchor it 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 (see fig. 3).

Next, look at 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 from the land behind it may signal a drainage problem. Weep (or drainage) holes are important for relieving the pressure of water that can build up behind an impermeable structure such as a seawall or concrete bulkhead. These holes should be inspected to make sure thay 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 a good bet that sediment has built up and is blocking proper drainage. 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 (see fig. 3).

Sand Fencing

On wide, sandy beaches, wooden or fabric fencing is used to encourage the deposition of windblown sand and create artificial 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 frequently 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 seaward 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 frequent 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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