University of Wisconsin Sea Grant Advisory Services **Pennants**

How to Use Fill Material in Stabilizing Shoreline Bluffs or Banks

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Fill material is commonly used to stabilize and restore bluffs along the Great Lakes shoreline. What many property owners don't realize is that the improper placement of fill may make their bluff or bank *more* unstable. An inadequate amount of fill at the bluff toe can quickly scatter under wave attack.

Concrete rubble fill is probably the cheapest and most widely practiced form of shore protection along Great Lakes coasts. It is also one of the most temporary types of shore protection, yet its negative effects can linger on the beach and in nearshore waters for decades as the rubble gradually but inevitably slides downward into the lake, making any beaches in front of filled areas unusable.

This *Pennants* is not an endorsement of the use of concrete rubble, but a recognition that many property owners use it and other fill as the only affordable shore protection measure they can take to save their property. Therefore, the following information explains the proper and improper placement of fill, how to go about determining where on the face of a bluff to add fill, and whether it will increase or decrease bluff stability. Be forewarned, however, that the correct placement of fill, combined with other measures, can be expected to only slow, not completely stop, coastal erosion.

Why Bluffs Fail

A bluff is stable as long as the soil's resistance to failure remains greater than the forces that can cause failure. In other words, a stable bluff is one that is stronger than the loads placed on it. These loads include the weight of the soil itself, any buildings and other bluff-top structures, and the water in the bluff. Bluff failure occurs when these loads become greater than the strength of the soil. The result is that sections of the bluff break loose and slide towards the lake. The slide material may be blocks of intact soil or loose granular particles.

Typically, a bluff will fail along a failure surface, or "slip circle" (see Figure 1). *There is no simple way to determine where the centers of failure (points 1 and 2 in Figure 1) are located.* Evidence of impending failure may not be visible on the bluff face or bluff top. In cases where bluff failure from the improper placement of fill would cause loss or severe damage to bluff top structures, a registered civil or geotechnical engineer should be consulted. The following information is intended to help you understand the risk to bluff stability, and the general solution to the problem of how to safely use fill to improve bluff stability.

Mistakes to Avoid

There are right and wrong ways to stabilize a bluff or bank. *If you do it the wrong way, you may increase the chances of bluff failure.* In addition, you may be made to pay a fine and/or pay for a costly clean-up.

The action of dumping fill can itself increase the chance of bluff failure. Driving a dump truck, crane or bulldozer to the bluff edge, or depositing the fill material near the bluff top, can add to bluff load and result in bluff failure.

Simply relying on fill to solve bluff erosion problems is to ignore the importance of groundwater. Groundwater in the bluff increases the chance that slumping will occur, as the water both adds to the soil load *and* "lubricates" the soil, weakening its resistance to failure.

Furthermore, some material used for fill is simply inappropriate for bluff stabilization and only adds trash to the lake. Fill made up of small rubble, asphalt pavement, reinforcing wire and rod, lumber, etc., will soon litter the lake water and lake bed.

Permits for placing shoreland fill below the Ordinary High Water Mark (OHWM) are required from the Wisconsin Department of Natural Resources, the U.S. Army Corps of Engineers and, in some locations, the county, town or city governments. The OHWM is the highest point on the shore where the presence and action of the lake water is frequent enough to leave a distinct mark by erosion, destruction of terrestrial vegetation, predominance of aquatic vegetation, or other easily recognized characteristics. A determination of the OHWM and approval

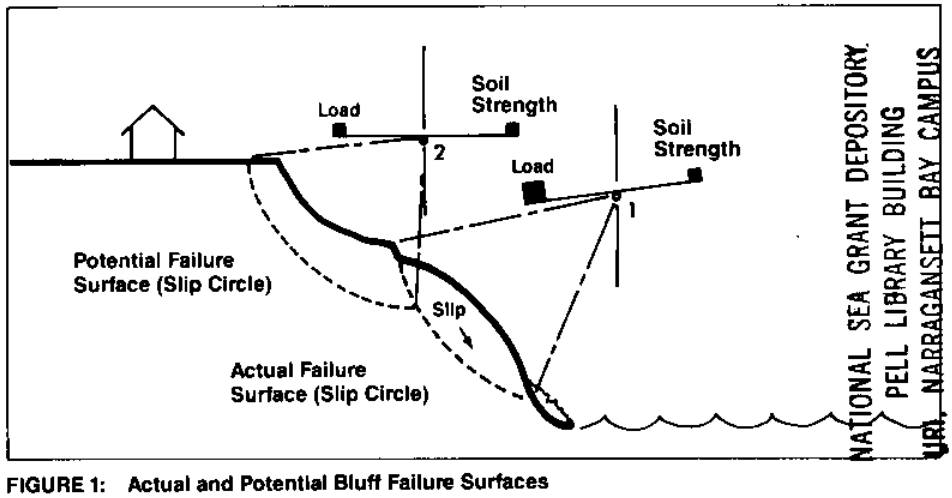

FIGURE 1: Actual and Potential Bluff Failure Surfaces

Points 1 and 2 are the imaginary centers of the "slip circles" of actual and potential bluff failures, respectively. Load vs. soil strength is depicted by the balance at each center. Bluff failure occurs when the total soil load exceeds the soil strength, as at Point 1. As long as load and soil strength remain relatively balanced, as at Point 2, the bluff remains stable. The chance of bluff failure can be reduced either by increasing the soil's strength (i.e., its resistance to failure), or by decreasing the bluff load.

of a permit requires a site inspection by a Wisconsin DNR water management specialist. The DNR permits also describe which materials cannot be used for fill.

Three Ways to Stabilize a Bluff

You can take three actions to stabilize a bluff, the order of which depends on the specific site conditions.

One step in stabilizing a coastal bluff or bank is to install "toe protection" at the base. Toe protection can do two things: (1) it prevents storm waves from eroding the bluff base and weakening the bluff, and (2) it may strengthen the bluff. Toe protection may consist of concrete rubble, a quarrystone riprap revetment, a bulkhead, a seawall, or some other type of structure at the base of the bluff or bank. Concrete rubble or quarrystone revetments can last for years if they contain a sufficient quantity of material appropriate to the size of rubble or stone used. Occasional replenishment of lost material may be needed.

Another step is to create a stable slope angle. This can be done by placing fill at the base of the slope, by regrading the slope, or by a combination of these two measures. A stable slope angle for the fine-grained glacial till of Wisconsin's Lake Michigan bluffs is generally no steeper than two and a half feet horizontal to one foot vertical. For Lake Superior's red clay bluffs, the stable slope is much flatter—slopes with more than three feet horizontal to one foot vertical are recommended.

The third step is groundwater and surface water runoff control. Any groundwater seeping from the bluff face weakens the soil's resistance to failure. Groundwater can be intercepted with shallow wells and sump pumps, or with one or more curtain drains on the bluff top and face. Water allowed to run down the face of the bluff erodes the soil and causes the bluff to recede. Such surface water runoff can be intercepted with earthen berms.

The sequence of these three steps varies depending on what must be done to accomplish bluff stabilization, as illustrated by the examples in Figures 2 and 3. In both examples, the placement of the filled material should not exceed the the overall stable slope angle. If the toe protection consists of concrete rubble or quarrystone of a size moveable by wave action, a sufficient quantity should be dumped or placed so as to allow wave energy to dissipate within the structure after the waves have reshaped the rubble or stone to a stable profile.

How to Add Fill to the Face of a Bluff or Bank

The best way to place fill material on the face of a bluff is to add fill from the base of the bluff and work upwards, using the same beach access used for constructing the toe protection, though sometimes it may be necessary to have the fill in place *before* constructing the toe protection as shown in Figure 3.

Another way to add fill is to construct a temporary chute down the bluff face. Material dumped in the chute at the top will slide to the base of the bluff and can be placed where desired. Move the chute as needed to distribute the fill.

A third way to place fill is with a truck-mounted crane and bucket. But remember that such heavy construction equipment should be kept far enough back from the bluff edge to avoid weakening it and causing a failure later. If concrete rubble fill is used, a top cover of soil can be added to provide a base for vegetation to grow.

Final Step: Vegetation

Ground cover vegetation on a bare slope is an important final step in stabilizing a bluff. For gentle slopes, seeding may be appropriate if a mulch or biodegradable net cover is used to hold the surface soil in place until the vegetation is established. A variety of shrubs and grasses can be planted and may work well, especially deeply rooted species.

Grass sod is expensive and difficult to establish on steep slopes. Sod has the obvious advantage of being less susceptible to washout than seeded slopes.

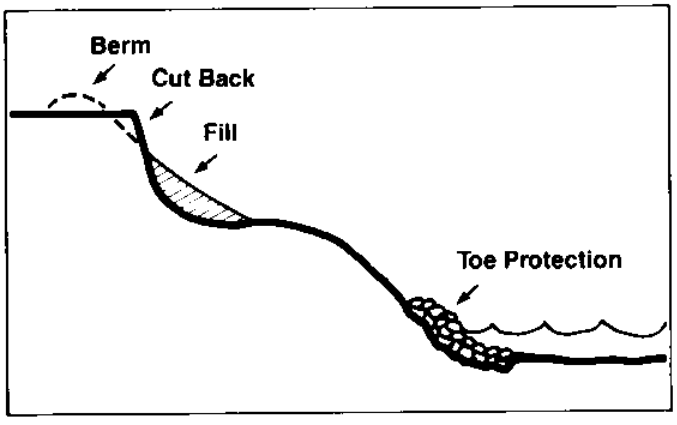

FIGURE 2: Steep, Unstable Upper Bluff; Gentle Slope at Mid-Bluff; Stable Lower Bluff Slope

In this case, the best place to put the fill is at the base of the unstable upper bluff. If the fill consists of fine-grained soil, a coarse gravel drainage layer should be laid down first. Care must be taken not to add so much fill that the lower part of the bluff becomes unstable. Cutting back the upper, unstable part of the bluff would also improve stability.

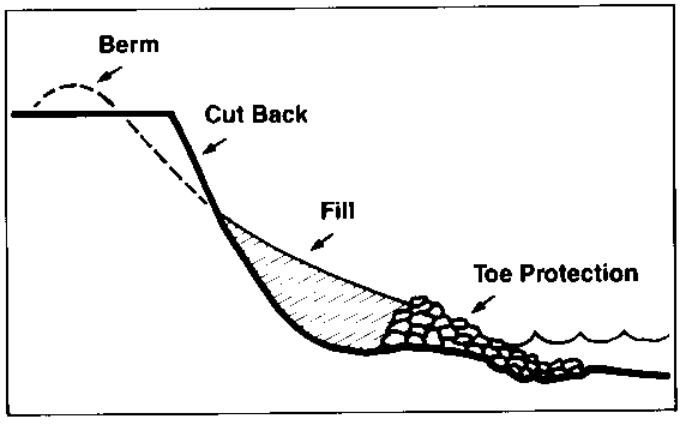

FIGURE 3: Entire Bluff Steep and Unstable

The *only* place to use fill in this case is at the base of the bluff, and progressively fill upwards on the slope. If the fill is mainly fine-grained soil, a coarse-gravel drainage layer should be added first. If space at the base of the bluff is adequate and the bluff is not too high, fill can sometimes be added to the full height of the slope, but be aware that the filled bluff top will not be able to bear as much load as the original bluff top. Cutting back the upper portion of the bluff will further improve stability.