General

A good maintenance program will protect a dam against deterioration and prolong its life. A poorly maintained dam will deteriorate and may fail. Nearly all the components of a dam and the materials used for its construction are susceptible to damaging deterioration if not properly maintained. A good maintenance program protects not only you, the owner but the general public as well. Moreover, the cost of a proper maintenance program is small compared to the costs of major repairs, or loss of life.

Develop a basic maintenance program based primarily on systematic and frequent inspections. Inspections should be performed at least monthly and after major floods or earth-quakes. During each inspection, refer to a checklist of items that call for maintenance

Maintenance should never be neglected. The following outline lists, by relative priority, the various problems or conditions that might be encountered in a dam that has deteriorated from lack of maintenance.

Immediate Maintenance

The following conditions are critical and call for immediate attention:

■ A dam about to be overtopped or being overtopped.

■ A dam about to be breached (by progressive erosion, slope failure, or other circumstances).

■ A dam showing signs of piping or internal erosion indicated by increasingly cloudy seepage or other symptoms.

■ A spillway being blocked or otherwise rendered inoperable, or having normal discharge restricted.

■ Evidence of excessive seepage appearing anywhere at the dam site increasing in volume.

Although the remedy for some critical problems may be obvious (such as clearing a blocked spillway), the problems listed above generally require the services of a professional familiar with the construction and maintenance of dams.

The following maintenance should be completed as soon as possible after the defective condition is noted:

■ Remove all underbrush and trees from the dam, and establish a good grass cover.

■ Fill animal burrows.

■ Restore and reseed eroded areas and gullies on embankment dams.

■ Repair defective spillways, gates, valves, and other appurtenant features.

■ Repair any concrete or metal components that have deteriorated, as soon as weather permits.

Continuing Maintenance

Several tasks should be performed continually:

■ routine mowing and general maintenance

■ maintenance and filling of any cracks and joints on concrete dams and in concrete spillways

■ observation of any springs or areas of seepage, comparing quantity and quality (clarity) with prior observations

■ inspection of the dam

■ monitoring of development in the watershed which would materially increase runoff from storms

■ monitoring of development down-stream and updating the emergency notification plan to include new houses or other occupied structures within the area

Specific Maintenance Items

Earthwork Maintenance and Repair

The surfaces of an earthen dam may deteriorate for several reasons. For example, wave action may cut into the upstream slope, vehicles may cause ruts in the crest or slopes, or runoff waters may leave erosion gullies on the downstream slope. Other special problems, such as shrinkage cracks or rodent damage, may also occur. Damage of this nature must be repaired continually. The maintenance procedures described below are effective in repairing minor earthwork problems. However, this section is not intended to be a technical guide, and the methods discussed should not be used to solve serious problems. Conditions such as embankment slides, structural cracking, and sinkholes threaten the immediate safety of a dam and require immediate repair under the direction of an engineer.

The material selected for repairing embankments depends upon the purpose of the earthwork. Generally, the earth should be free from vegetation, organic materials, trash, and large rocks. Most of the earth should be fine-grained soils or earth clods that easily break down when worked with compaction equipment. The intent is to use a material that, when compacted, forms a firm, solid mass, free from excessive voids.

If flow-resistant portions of an embankment are being repaired, materials that are high in clay or silt content should be used. If the area is to be free draining or highly permeable (riprap bedding, etc.), the material should have a higher percentage of sand and gravel. It is usually satisfactory to replace or repair damaged areas with soils similar to those originally in place.

An important soil property affecting compaction is moisture content. Soils that are too dry or too wet do not compact well. One may roughly test repair material by squeezing it into a tight ball. If the sample maintains its shape without cracking and falling apart (which means it is too dry), and without depositing excess water onto the hand (which means it is too wet), the moisture content is probably near the proper level.

Before placement of earth, prepare the repair area by removing all inappropriate material. Clear vegetation such as brush, roots, and tree stumps, along with any large rocks or trash removed. Also, unsuitable earth, such as organic or loose soils, should be removed, so that the work surface consists of exposed, firm, clean embankment material.

Following cleanup, shape, and dress the affected area so that the new fill can be compacted and will properly tie into the existing fill. If possible, trim slopes and roughen surfaces by scarifying or plowing to improve the bond between the new and existing fill and to provide a good base to compact against. Grade the slopes in a direction such that the soil ridges are parallel to the length of the dam—this will help to minimize or reduce rill erosion. Roughening in the wrong direction will likely increase rill erosion.

Place soils in loose layers up to eight inches thick and compacted manually or mechanically to form a dense mass free from large rock or organic material. Maintain soil moisture in the proper range. The fill should be watered and mixed to the proper wetness or scarified and allowed to dry if too wet.

During backfilling, take care that the fill does not become too wet from rainstorm runoff. Direct runoff away from the work area and overfill repair areas so that the fill maintains a crown that will shed water.

As mentioned earlier, occasionally minor cracks will form in an earthen dam because of surface drying. These are called desiccation (drying) cracks and should not be confused with structural or settlement cracks. Drying cracks are usually parallel to the main axis of the dam, typically near the upstream or downstream shoulders of the crest. These cracks often run intermit-tently along the length of the dam and may be up to four feet deep. Drying cracks can be distinguished from more serious structural cracks because the former are usually no wider than a few inches and have edges that are not offset vertically.

As a precaution, initially monitor suspected desiccation cracks with the same care used for other types of cracks. The problem area should be marked with survey stakes, and monitoring pins should be installed on either side of the crack to allow recording of any changes in width or vertical offset. Once you are satisfied that observed cracking is the result of shrinkage or drying, you may stop monitoring.

These cracks should close as climatic or soil moisture conditions change. If they do not, it may be necessary to backfill the cracks to prevent the entry of surface mois-ture, which could result in saturation of the dam. The cracks may be simply filled with earth that is tamped in place with hand or tools. It is also recommended that the crest of a dam be graded to direct runoff waters away from areas damaged by drying cracks.

Erosion is one of the most common maintenance problems at embankment structures. Erosion is a natural process and its continuous forces will eventually wear down almost any surface or structure. Periodic and timely maintenance is essential to prevent continued deterioration and possible failure.

Sturdy sod, free from weeds and brush, is an effective means of preventing erosion. Embankment slopes are normally designed and constructed so that surface drainage will be spread out in thin layers (sheet flow) on the grassy cover. When embankment sod is in poor condition or flows are concentrated at any location, the resulting erosion will leave rills and gullies in the embankment slope. An owner should look for such areas and be aware of the problems that may develop. Eroded areas must be promptly repaired to prevent more serious damage to the embankment. Rills and gullies should be filled with suitable soil (the upper four inches should be topsoil, if possible), compacted, and then seeded. Erosion in large gullies can be slowed by stacking bales of hay or straw across the gully until permanent repairs can be made.

Not only should eroded areas be repaired, but the cause of the erosion should be found to prevent a continuing maintenance problem. Erosion might be caused or aggravated by improper drain-age, settlement, pedestrian traffic, animal burrows, or other factors. The cause of the erosion will have a direct bearing on the type of repair needed.

Paths due to pedestrian, livestock, or vehicular traffic (two- and four-wheeled) are a problem on many embankments. If a path has become established, vegetation will not provide adequate protection and more durable cover will be required unless traffic is eliminated. Small stones, asphalt, or concrete may be used effectively to cover footpaths. In addition, railroad ties or other beams of treated wood can be embedded into an embankment slope to form an inexpensive stairway. All vehicular traffic, except for maintenance, should be prohibited from the dam.

Riprap Maintenance and Repair

A serious erosion problem called benching can develop on the upstream slope of a dam. Waves caused by high winds or high-speed boats can erode the exposed face of an embankment by repeatedly striking the surface just above the pool elevation, rushing up the slope, then tumbling back into the pool. This action erodes material from the face of the embankment and displaces it down the slope, creating a “bench.” Erosion of unprotected soil can be rapid and, during a severe storm, could lead to the complete failure of a dam.

The upstream face of a dam is commonly protected against wave erosion and resultant benching by placement on the face of a layer of rock riprap over a layer of filter material. Generally, rock riprap offers the most economical and effective protection.

Nonetheless, benching can occur in existing riprap if the embankment surface is not properly protected by a filter. Water running down the slope under the riprap can erode the embankment. Sections of riprap that have slumped downward are often signs of this kind of benching. Similarly, concrete facing used to protect slopes may fail because waves wash soil from beneath the slabs through joints and cracks. Detection is difficult because the voids are hidden, and failure may be sudden and extensive. Effective slope protection must prevent soil from being removed from the embankment.

When erosion occurs and benching develops on the upstream slope of a dam, repairs should be made as soon as possible.

A riprap layer should extend a mini-mum of 3 ft below the lowest expected normal pool level. Otherwise, wave action during periods of low lake level will undermine and destroy the protection.

If rock riprap is used, it should consist of a heterogeneous mixture of irregular shaped stone placed over a sand and gravel filter or filter fabric. The biggest rock must be large and heavy enough to break up the energy of the maximum expected waves and hold smaller stones in place. The smaller rocks help to fill the spaces between the larger pieces and to form a stable mass. The filter prevents soil particles on the embankment surface from being washed out through the spaces between the rocks in the riprap.

A dam owner should expect some riprap deterioration because of weathering. Freezing and thawing, wetting and drying, abrasive wave action and other natural processes will eventually break down the material. Therefore, allocate sufficient funds for the regular replacement of riprap.

The useful life of riprap varies depending on the characteristics of the stone used. Thus, stone for riprap should be rock that is dense and well cemented

When riprap breaks down, and erosion and beaching occur more often than once every three to five years, professional advice should be sought to design more effective slope protection.

Controlling Vegetation

Keep the entire dam clear of unwanted vegetation such as brush or trees. Excessive growth may cause several problems:

■ It can obscure the surface of an embankment and prevent a thorough inspection of the dam.

■ Large trees can be uprooted by high wind or erosion and leave large holes that can lead to breaching of the dam.

■ Some root systems can decay and rot, creating passageways for water, and thus causing erosion.

■ Growing root systems can lift concrete slabs or structures.

■ Trees, brush, and weeds can prevent the growth of desirable grasses.

■ Rodent habitats can develop.

When brush is cut down, it should be removed to permit a clear view of the embankment. Following removal of large brush or trees, also remove their leftover root systems, if possible, and properly fill and compact the resulting holes.

If properly maintained, the grass is not only an effective means of controlling erosion—it also enhances the appearance of a dam and provides a surface that can be easily inspected. Grassroots and stems tend to trap fine sand and soil particles, forming an erosion-resistant layer once the plants are well established. Grass is least effective in areas of concentrated runoff or in areas subjected to wave action.

Controlling Animal Damage

Livestock should not be allowed to graze on an embankment surface. When soil is wet, stock can damage vegetation and disrupt the uniformity of the surface. Moreover, livestock tend to walk in established paths and thus can promote severe erosion. Such paths should be regraded and seeded, and the livestock permanently fenced out of the area.

Burrowing animals are naturally attracted to the habitats created by dams and reservoirs and can endanger the structural integrity and proper performance of embankments and spillways. The burrows and tunnels of these animals generally weaken earthen embankments and serve as pathways for seepage from the reservoir. This kind of damage has resulted in several failures of dams; therefore, controlling burrows is essential to their preservation.

Barriers such as properly constructed riprap and filter layers offer the most practical protection from these animals. Filter layers and riprap should extend at least three feet below the waterline. Heavy wire fencing laid flat against a slope and extending above and below the waterline can also be effective. Eliminating or reducing aquatic vegetation along a shoreline will also discourage habitation.

Methods of repairing rodent damage depend upon the nature of the damage but, in any case, the extermination of the rodent population is the required first step. If the damage consists mostly of shallow holes scattered across an embankment, repair may be necessary to maintain the appearance of the dam, to keep runoff waters from infiltrating the dam, or to discourage rodents from subsequently returning to the embankment. In these cases, tamping of earth into the rodent hole should be sufficient repair. Soil should be placed as deeply as possible and compacted with a pole or shovel handle.

Occasionally, rodents will dig passages all the way through the embankment that could result in leakage of reservoir water, piping, and ultimate failure. In those cases, do not plug the downstream end of the tunnel since that will add to the saturation of the dam. Tunnels of rodents or ground squirrels will normally be above the phreatic surface with primary entrance on the downstream side of the dam, If a rodent hole extends through the dam, first locate its upstream end. Excavate the area around the entrance and then backfill it with impervious material, plugging the passage entrance so that reservoir water is prevented from saturating the dam’s interior. This should be considered a temporary repair.

Controlling Damage From Traffic

As mentioned earlier, vehicles driving across an embankment dam can create ruts in the crest if it is not surfaced with roadway material. The ruts can then collect water and cause saturation and softening of the dam. Other ruts may be formed by vehicles driving up and down a dam face; these can collect runoff and cause severe erosion. Vehicles, except for maintenance, should be banned from dam slopes and kept out by fences or barri-cades. Repair any ruts as soon as possible using the methods outlined above.

Concrete Maintenance

Also as mentioned, periodic maintenance should be performed on all concrete surfaces to repair deteriorated areas. Repair deteriorated concrete immediately when noted; it is most easily repaired in its early stages. Deterioration can accelerate and, if left unattended, can result in serious problems or dam failure. Consult a professional to determine both the extent of deterioration and the proper method of repair. Seal joints and cracks in concrete structures to avoid damage beneath the concrete.