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From: B. Mukherjee
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To: 1) The Chief Engineer (West)
I & W Directorate
P.O.- Sadhanpur (Near Polytechnic)
Dist.- Burdwan
PIN- 713101.

2) Chief Engineer, North
I & W Directorate
Netaji More Market Complex,3rd floor
Saraju Prasad Road, Dist.- Malda
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3) The Chief Engineer (South-West)
I & W Directorate
Khusjungle, P.O. Abas
Dist.-Paschim Medinipur
PIN- 721102.

Sub: Forwarding "Routine Maintenance Guide for Dams" .

The undersigned is directed to inform that the Dam Safety Organization after conducting premoon visits to 13 (thirteen) large dams of this department, has prepared a guidelines to be followed for routine maintenance of the dams to ensure its safety. A copy of the same guidelines is enclosed for taking necessary actions by the working divisions for reference.

Enclo: As stated.

(B. Mukherjee)
Deputy Secretary to the
Govt. of West Bengal

ROUTINE MAINTENANCE GUIDE

1.Vegetation Control:-

All types of woody, deep rooted vegetation and brush growing on dam embankments or in the spillway should be controlled. Excessive vegetation growth on the dam causes the following problems as far as safety of the dam is concerned.

a) The view of the dam inspector is obstructed due to heavy vegetation. Consequently, obscurs any cracking seepage and other surficial indications of a problem associated with the dam.
b) The decayed root systems of dead trees and brush may form tunnels in the dam through which water can pass (piping).
c) The root system of large trees may be uprooted during windstorms forming a large hole in the embankment that would lead to breaching.
d) Vegetation on the embankment provides habitat for burrowing animals, whose presence further endangers the dam.

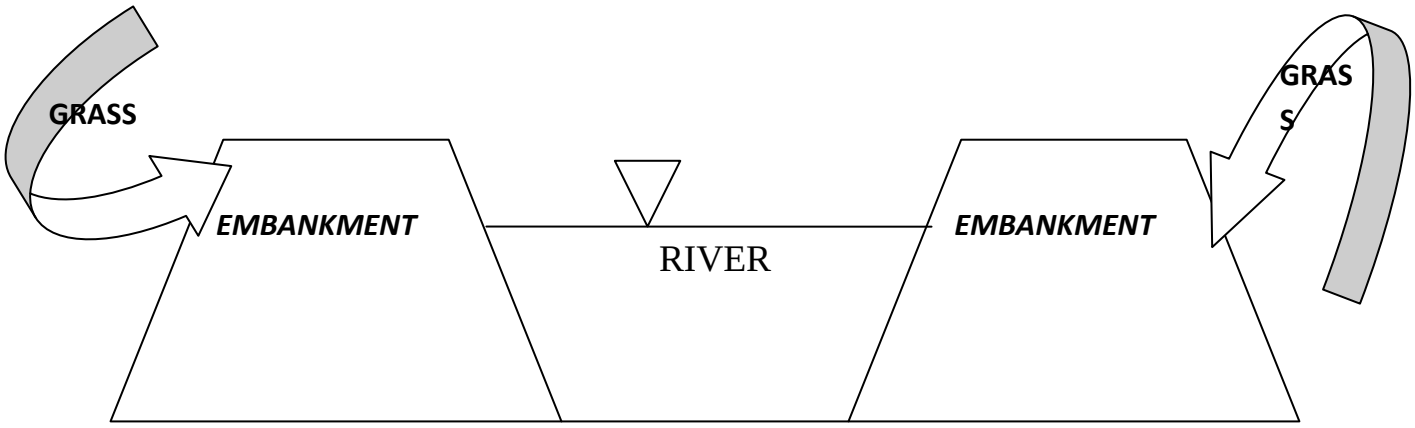
As a general statement for all trees, killing trees over about 6 feet tall on the dam must also be accompanied by excavating the roots and recompacting clean fill material into the excavation. This should be done in a radius extending from the trunk equal to the height of the tree or until the laterally extending roots are less than about half inch in diameters.

Policy:-

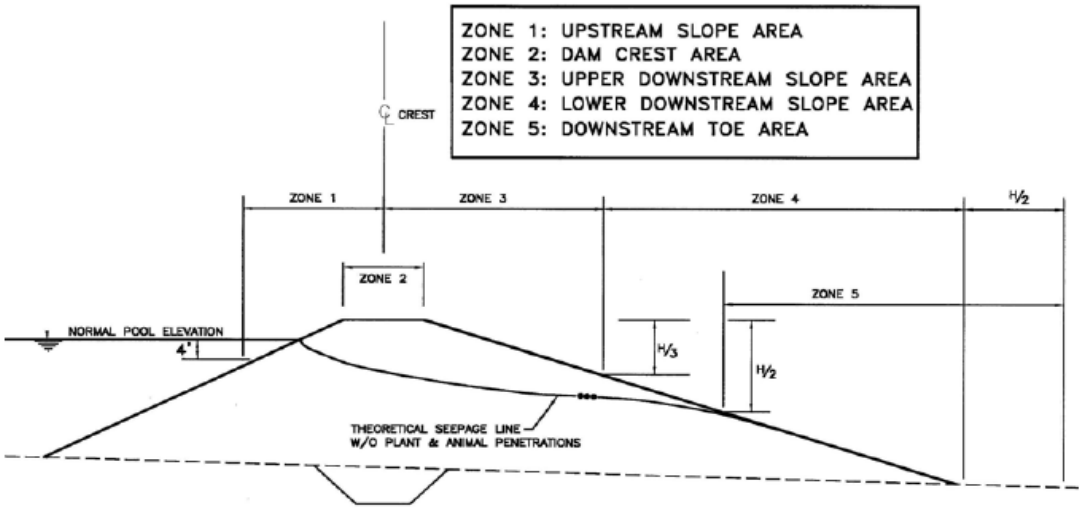
All brush and trees should be prevented from growing:-

i) On the dam itself and within 50 ft of the dam.
ii) In the spillway and within 50 ft of the spillway.
iii) Near the spillway or outlet channels such that flow through those structures in reduced or water backs up on the embankment.

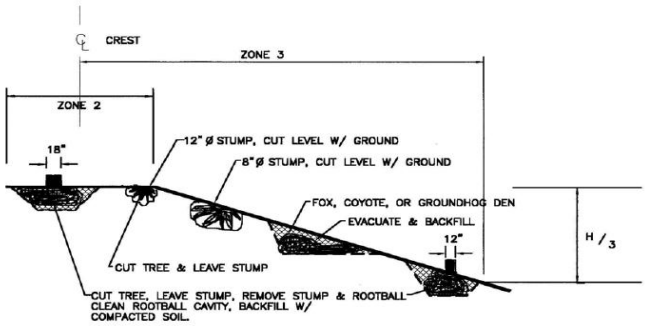
Only grasses which do not obscure observations of the embankment should be allowed to grow on the dam itself.



There are five zones in the dam which is shown in the figure below:



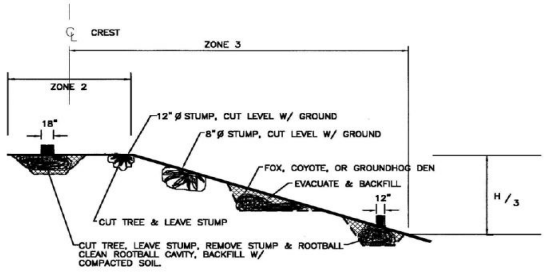
Remedial Repair Zone	Procedures and Techniques
Zone 1	Remove all trees, stumps, rootballs, and root system; clean rootball cavity; and backfill with properly placed and compacted soil backfill. Install tree and woody vegetation and wave erosion protection system on the upstream slope from about four feet below normal pool elevation to about three feet above normal pool elevation.
Zone 2	Cut trees in overlap area of Zone 2 and Zone 3 having stump diameters of twelve inches or less flush with the ground and treat the stump with a waterproof sealant to prolong stump decay.



ZONE 2 & 3 REPAIR PROCEDURES

Completely remove trees having stump diameters of about twelve inches and greater, and backfill rootball cavity with properly compacted backfill soil.

Zone 3

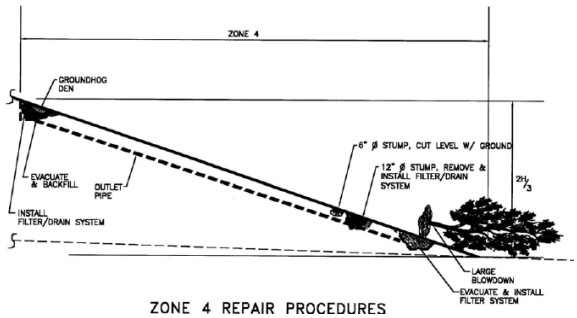


ZONE 2 & 3 REPAIR PROCEDURES

Cut trees having stump diameters of about eight inches and less level with the ground and treat the stump with a waterproof sealant to prolong stump and rootball decay.

Completely remove all trees having stump diameters greater than about eight inches and backfill the cleaned rootball cavity with compacted backfill soil.

Zone 4

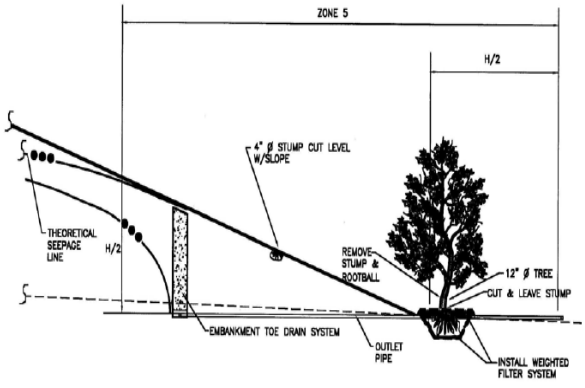


ZONE 4 REPAIR PROCEDURES

Cut all trees having stump diameters of six inches or less flush with the ground and treat the stump with a waterproof sealant to prolong stump and rootball decay.

Remove all trees having stump diameters greater than about six inches, install subdrain and/or filter systems, and backfill with properly compacted soil around the filter/drain system.

Zone 5



ZONE 5 REPAIR PROCEDURES

Cut all trees having stump diameters of about four inches and smaller flush with the ground and treat the stump to prolong stump and rootball decay.

Install a major embankment toe drain or subdrain system to lower the phreatic surface, filter, collect, and discharge embankment seepage. Incorporate major subdrain with tree rootball and stump removal where possible.

Remove all trees located beyond the toe of the downstream slope having stump diameters greater than about four inches. Install weighted filters and/drain systems in rootball cavities where seepage boiling and soil piping is likely to occur.

2. HERBICIDE APPLICATION

Several formulations of herbicides suitable for tree and brush control are available. They can be foliar applied or soil applied and consists of liquid spray solutions, granules, and pellets. Here is a brief description of common application methods:

Foliar applications consist of spraying the chemical directly on to the target plant, especially the leaves. It is necessary to thoroughly cover all above ground vegetation on the plant to the point of runoff. Foliar applications need to be made in the late spring or early summer when plants are actively growing and new growth is young and succulent. In many plants, the heat of summer causes the tree to develop a waxy layer on the leaves which inhibits absorption of foliar applied herbicides into the plant. Also, the tree may become coated with dust as the summer progresses. Both of these factors reduce the effectiveness of foliar applied herbicides.

Soil treatment consists of applying the herbicide directly to the soil around the target plant. These treatments are intended to be moved into the soil by precipitation and can remain active for several years. If significant quantities of low lying vegetation exist around the target plant, it may be necessary to remove that vegetation and perhaps scarify the soil to obtain acceptable results. Time of year of these applications is not as critical as with foliar sprays since the herbicide is taken into the plant through the roots.

***These chemicals are often restricted from use where they may come into contact with irrigation waters, and all precautions and instructions on the labels of herbicides should be followed. They should not be used around the upstream side of the dam nor areas where surface water could move the chemical into conveyance structures.*

Frill method consists of making cuts at a convenient height in a circle completely around a tree with downward axe strokes. These cuts should extend well into the sapwood and the sapwood be continuously exposed around the tree. The frilled area is then saturated with herbicide.

Cut stump method consists of cutting the tree and spraying or painting herbicide onto the remaining stump. Best results are obtained by treating the stump immediately following cutting. Care should be taken to ensure thorough coverage of the area just inside of the bark of the tree.

3. HERBICIDE SELECTION

Translocated herbicides (herbicides which are moved from the place of application to other parts of the plant e.g., moved from the leaves to the roots.) are the main types which are useful for control of vegetation detrimental to dams. These herbicides should be applied when the vegetation is growing and is not dormant. One commonly used herbicide which is not translocated is glyphosate (Tradename --Roundup).
Choice of a specific herbicide will normally be decided by where it is to be applied and the proximity of this area to irrigation water rather than the type of vegetation targeted.

****Extra care needs to be taken in selecting a herbicide for application to vegetation on the upstream side of the dam since some herbicides may contaminate the irrigation supply and result in damage to crops.*

4. BURROWING ANIMAL CONTROL

Some of the typical burrowing animals which damage dams are squirrels, rats, fox, crabs, pigs. They may create shallow den, which may create instability of the earthen dam embankment. Sometimes they created large hole which will affect the core portion of the earthen embankment. Proper maintenance of embankment of dams require that these animals be prevented from burrowing on the dam and that they be eradicated if they are present on a dam.

Routine inspection of the embankment is required by the Dam owner. If there is any problem noticed regarding rodent, immediate necessary action should be taken by the concern owner. The material selected for repairing embankments depends upon the purpose of the earthwork. Generally, earth should be free from vegetation, organic materials, trash, or large rock. Most of the earth should be fine-grained soils or earth clods which easily break down when worked with compaction equipment.

5. OTHER EMBANKMENT MAINTENANCE

Deterioration of the surfaces of an earth dam may occur for several reasons for example

1.) W*ave action may cut into the upstream slope*
2.) V*ehicles may cause ruts in the crest or slopes*
3.) Runoff waters may leave erosion gullies on the downstream slope.

Damage of this nature must be repaired on a continuing basis. The maintenance procedures described below are effective in repairing minor earthwork problems. The material selected for repairing embankments depends upon the purpose of the earthwork. Generally, earth should be free from vegetation, organic materials, trash, or large rock. Most of the earth should be fine-grained soils or earth clods which easily break down when worked with compaction equipment. The intent is to use a material which, when compacted, forms a firm, solid mass, free from excessive voids. If flow-resistant portions of an embankment are being repaired, materials which are high in clay or silt content should be used. If the area is to be free draining or highly permeable (i.e., riprap bedding, etc.) the material should have a higher percentage of sand and gravel. As a general rule, it is usually satisfactory to replace or repair damaged areas with soils similar to those originally in place.

6. CREST OF DAM

A dam's crest usually provides the primary access for inspection and maintenance. Because surface water will pond on a crest unless that surface is well maintained, this part of a dam usually requires periodic regrading. However, problems found on the crest should not be simply graded over or covered up.

Surface runoff should be directed toward the upstream face of the dam by having the crest graded toward the reservoir. Less erosion will result since the upstream face of the dam is usually armoured with riprap, the slope is normally flatter and the distance from the crest to the reservoir level is less that from the crest to the downstream toe.

Traffic damage control - As mentioned earlier, vehicles driving across an embankment dam can create ruts in the dam crest if the crest is not surfaced with a suitable road base 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 ruts can collect runoff and result in severe erosion. Vehicles should be banned from dam slopes and kept out by fences or barricades. Any ruts should be repaired as soon as possible it observed by the concern authority.

Excessive settlement of the embankment or foundation can result in a low area in the dam crest and loss of the freeboard (*freeboard is the vertical distance between the top of the spillway and the top of the dam*) necessary to pass flood flows safely through the spillway. The dam crest should be surveyed, the probable cause for the formation of the low spot determined by an engineer, remedial action taken to correct the problem and then a uniform crest should be re-established by placing fill in low areas using proper construction techniques.

7. SLOPES OF THE DAM

Livestock access to the dam embankment should be controlled through installation of proper fencing. The main problem associated with livestock on the embankment is erosion caused by excessive travel by livestock, especially during periods of wet weather, overgrazing of protective grasses and disruption of riprap.

Effective slope protection must prevent soil from being removed from the embankment. Slope protection will require routine maintenance to assure satisfactory long term operation. Weathering can deteriorate poor quality riprap, breaking it into sizes which are too small to resist wave action. Rounded, similar size rocks have a tendency to roll downhill. Similar sized rocks allow waves to pass between them washing out the finer gravels and sand, causing the riprap to settle. Riprap needs to be replaced anytime the finer material of the bedding is exposed. When riprap breaks down and erosion and beaching occur more often than once every three to five years, it may be necessary to place new bedding and riprap material which has been designed with the gradation and size that will assure its stability when subjected to wave action and weathering.

Recreationist damage at the upstream and downstream slope protection that should be strictly prohibited with proper arrangement.

8. DRAINS, PIEZOMETERS AND WEIRS

Drains should be maintained open, this may require occasional reaming and cleaning. The drain outfall channel should be sloped to prevent ponding.

Piezometers should be equipped with a surface casing and locking lid to protect them from vandalism. The piezometer pipe should have a cap to keep soil or water from entering it.

Piezometers casings located in or near traffic areas should be protected from vehicular damage.

Weirs and Weir Ponds should be maintained free from weeds and trash. Sediments accumulating behind weirs installed to measure seepage should be monitored with their quantities measured and noted at the time they are cleaned out. The crest of the weir should be checked periodically to assure that it is level and should also be checked with reference to the zero of the gage. The downstream channel should be adequately sloped to prevent water ponding at the base of the weir.

9. OUTLET MAINTENANCE

All gates should be operated at least twice a year. Gates that have not been operated for a long time can present a special problem for dam owners. If the gate cannot be closed after it is opened, the impoundment could be completely drained. An uncontrolled and rapid drawdown could also cause more serious problems such as slides along the saturated upstream slope of the embankment or downstream flooding. Therefore, when a gate is operated, it should be inspected and all appropriate parts lubricated and repaired.

Sediments can build up and block the drain inlet, or debris can enter the valve chamber, hindering its function. The likelihood of these problems is greatly decreased if the valve or gate is operated and maintained conscientiously.

10. GATE OPERATION

Electricity is often used on dams to operate the outlet gates, provide lighting and operate other electrical equipment. Thus, it is important that the electrical system be well maintained. Maintenance should include a thorough check of the fuses and a test of the system to be sure everything is properly functioning. Moisture and dust should be kept away from the electrical system, and wiring should be checked for corrosion and mineral deposits. Any necessary repairs should be completed immediately, and records of the repair work should be kept. In addition, generators kept for back-up emergency power must be maintained. Maintenance should include oil changes, battery checks, and making sure that fuel is readily available.

11. OUTLET INSPECTIONS

Inspecting the outlet system should be done by entering all accessible portions of the structure including the conduit if it is large enough. While inside the conduit it should be tapped with a hammer to help locate possible voids behind the pipe. All joints, connections and vents should be checked for leakage or damage. Any material obstructing the conduit should be removed.

12. SPILLWAY MAINTENANCE

Obstructions of a spillway may result from excessive growth of grass, weeds, brush, trees, debris, landslide deposits, or rocks placed in the spillway by recreationists. Any of these obstructions can reduce the capacity of a spillway and lead to overtopping of the dam. The installation of log booms can help to prevent floating debris from entering the spillway. Any obstructions in the spillway should be promptly removed so that the spillway can pass its design capacity.

Cracks in the concrete lining of a spillway are commonly encountered. Hairline cracks are usually of no real consequence, but large cracks are of concern. These cracks may be caused by loss of foundation support, shrinkage, movement of the structure, or excessive earth or water pressure. A severely cracked spillway should be examined and repaired under the supervision of an engineer. The concern authority require continuous monitoring of cracks or other deficiencies such as tilting walls and will assist owners in setting up a monitoring program if the owner so desires.

Vertical walls of a spillway are usually equipped with **"weep holes".** These holes are intended to drain water from the soil behind the walls and help to prevent damage to the walls from water pressure. If some weep holes flow but others do not, it possible that those which do not flow may be plugged. Any mud, mineral deposits or other obstructions accumulated in weep holes should be removed. Properly functioning weep holes can prolong the life of all concrete walls.

13. RESERVOIR BASIN

Sediment build-up in the reservoir is usually due to destabilization of upstream drainages. A comprehensive basin management plan which emphasizes erosion control, retention of vegetation and environmentally sound stream channel stabilizations practices would be the most effective solution to the sediment problems. Dredging of the reservoir would forestall the loss of capacity but removing the sediment source would be much more effective.

Sinkholes in the reservoir basin, especially adjacent to the embankment, may be indicative of internal erosion (piping) of the embankment material. All sinkholes should be brought to the attention of the concern dam owner and monitored for any significant changes.

14.LIGHTING

Lighting is one of the important aspects for the dam owners. Lighting ensures safety of dam, and it helps to check the gauge level mainly at the emergency situation and gate operation at night time. Dam owner should maintain proper lighting throughout the dam.

15. COMMUNICATION:

As per IS 9296 – 2001 Cl.6.5 Alternate and emergency lighting, flood warning and communication systems shall be properly maintained.

16. GAURDING

Dam owner should ensure proper guarding arrangement of dam and its ancillary parts round the clock for safety.

17. SIGNS OF EMBANKMENT DISTRESS:

Structural problems with the embankment may be exhibited in the embankment itself, the foundation of the dam, or the abutments. Many of these types of problems become evident early in the life of the dam, often during the first reservoir filling. Symptoms of structural problems are seepage, cracking, movement, settlement, sinkholes and erosion.

Seepage which is causing piping may create a sand boil where the water emerges. If new seepage areas develop, an increase in existing seepage occurs, or sand boils develop, the dam owner should attend the problem immediately.

Cracking can occur in a variety of places on the dam. Foundation problems or an embankment weakness can be manifested by cracks. Emptying the reservoir quickly can cause cracks on the upstream side of the dam. Randomly oriented, shallow cracks are usually attributable to drying of the surface soils on the dam. Cracks of any sort should be reported by the dam owner immediately.

Movement of the embankment can occur as a slough or slide. If any movement of embankment or abutment material occurs, the concern dam owner should take immediate necessary action to overcome the problem.

Erosion of the embankment can result from inadequate protection of the dam from wave action or from rain collecting and running down the face of the dam. Waves create steps, sometimes called beaches and benches, along the upstream face of dams. Erosion of the upstream face of the dam should be corrected by placing an adequate layer of properly graded riprap.

18. MISCELLANEOUS :

In case of concrete / masonry dams following points shall be taken for their maintenance.

I. Drainage system in the foundation and the dam body shall be maintained properly.

II. Leaks, cracks and spalling on the surface of the dam and in opening like gallery and adits shall be treated.

III. Leaks, cracks, slides, etc. in the abutment shall be treated.

IV. Measure shall be taken to protect against harmful retrogression.

V. No blasting operation shall be permitted to be carried on or near the dam except as permitted in IS -6922

VI. Access to vital parts and adequacy of lighting facilities shall be ensured.

VII. All weather accessibility of approach road to dam site shall be ensure.

VIII. Emergency lighting system shall be properly maintained.

IX. Any debris or rock pieces collected in the energy dissipation structures / surplussing arrangement shall be removed before monsoon. Cleaning beyond these structures

shall be done to the extent required. After monsoon or for periods when the spillway and outlets therein are not to be operated, the energy dissipation structures shall be examined for erosion, retrogression, normal wear and tear for undertaking repairs. Such repairs shall be undertaken expeditiously to bring the energy dissipation structure to a safe operating condition before being operated for the next monsoon floods.

X. Leaks, Cracks and spallings on the spillway piers, under sluices and outlets shall be treated.

Sri Bankesh Ojha
Assistant Director
Dam safety Organization