



Guidelines for Operation and Maintenance of Dams in Texas



TEXAS COMMISSION ON
ENVIRONMENTAL QUALITY

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Introduction

Welcome to Dam Safety

The need for dam safety is urgent. Across the United States, thousands of dams are now in place, with many more built each year. Dams—essential elements of the national infrastructure—supply water for households and businesses and cooling water for power plants, offer opportunities for recreation, and help control floods. Should a dam fail, many lives and many dollars' worth of property are at risk. The legal and moral responsibility for dam safety rests with you—the dam owner.

Existing dams are aging and new ones are being built in hazardous areas. At the same time, development continues in potential inundation zones downstream. More people are at risk from dam failure than ever, despite better engineering and construction methods, and continued deaths and property losses from dam failures are to be expected.

Society and individuals alike may profit from dam operations. Dam ownership, however, is neither justified nor effective if one cannot assure the safety of citizens and property. The costs of dam safety are small in comparison to the consequences following a dam failure, particularly in today's litigious society. Liability due to dam failure can easily offset years of profitability.

You can directly influence the safety of a dam by developing a safety program

which includes inspection, monitoring through instrumentation, maintenance of the structure, and proactive emergency planning. A high-quality safety program is attuned to the dam structure and its immediate environment and depends on the owner's knowledge of the dam and how it works.

Introduction to Dams

Dams may either be human-built or exist because of natural causes, such as landslides or glacial deposition. The majority of dams are human structures constructed of earthfill or concrete. It is important that you, as a dam owner, be aware of the different types of dams, their essential components and how those components function, and important physical conditions likely to influence them.

Hazards, Risk, Failures

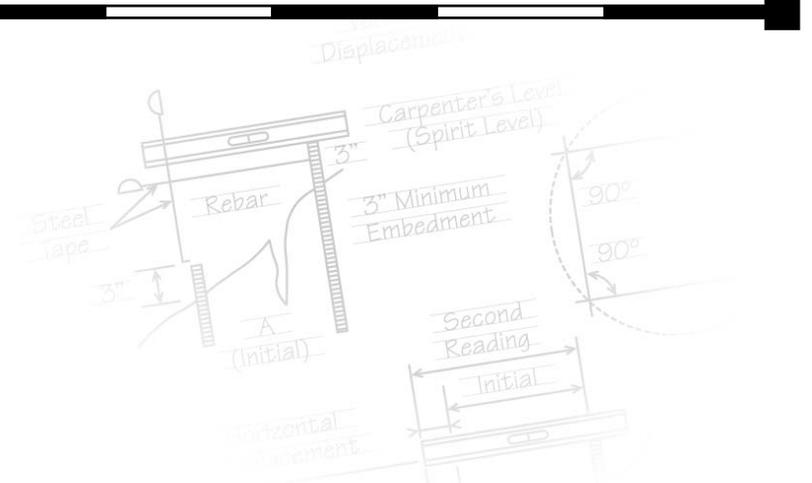
Present national statistics on losses from dam failure fully justify the need for you to better understand the risks involved with dam ownership, the kinds of hazards that promote these risks, and the reasons dams fail. Risk is high because people have been allowed to settle below dams in potential inundation zones, and new dams are being built at sites that are less than ideal geologically.

Other risks include natural phenomena such as floods, earthquakes, and landslides. These hazards threaten dam structures and their surroundings. Floods that exceed the capacity of a dam's spillway and then erode the dam or abutments are particularly hazardous, as is seismic activity that may cause cracking or seepage. Similarly, debris from landslides may block a dam's spillway and cause an overflow wave that erodes the abutments and ultimately weakens the structure.

The three major categories of dam failure are overtopping by flood, foundation defects, and piping. For earthen dams, the major reason for failure has been piping or seepage. For concrete dams, the major reasons for failure have been associated with foundations. Overtopping has been a significant cause of dam failure, primarily where a spillway was inadequate.

Developing a Dam-Safety Program

Recognition of the causes and possible impacts of dam failure points the need for a program to enhance dam safety. Such a program must be based on a safety evaluation to determine a dam's structural and operational condition. The evaluation should identify problems and recommend either remedial repairs, operational restrictions and modifications, or further studies and analyses to determine solutions.



A safety program comprises several components that address the spectrum of possible actions to be taken over the short and long term. Development of a safety program takes place in phases, beginning with collection and review of existing information, proceeding to detailed inspections and analyses, and culminating with formal documentation. Much of the preliminary work can be accomplished by the dam owner with the assistance of state and local public agencies. Professional assistance by qualified engineers and contractors may be required, however, depending upon the number and seriousness of problems identified during the initial assessment.

This manual offers direction on how to increase the safety of a dam and details technical and procedural components of the safety program ; necessary forms appear in the appendixes.

The program of inspection for both the initial and continuing safety evaluations establishes the condition of the dam and gathers the information necessary for determining specific actions regarding repairs, operations, and monitoring. The program is cyclical, recognizing the need for continued vigilance. Emergency action can, it is hoped, be avoided, but a well-thought-out plan of action in case of imminent or actual failure can greatly reduce damage and possible loss of life.

Inspection Guidelines

An effective inspection program is essential to identification of problems and for safe maintenance of a dam. The program should involve three types of inspections: (1) periodic technical inspections; (2) periodic maintenance inspections; and (3) informal observations by project personnel as they operate the dam. Technical inspections involve

specialists familiar with the design and construction of dams and include assessments of structure safety. Maintenance inspections—performed more frequently than technical inspections in order to detect, at an early stage, any detrimental developments in the dam—involve assessment of operational capability as well as structural stability. The third type of inspection is actually a continuing effort by on-site project personnel (dam tenders, powerhouse operators, maintenance personnel) performed in the course of their normal duties.

Instrumentation and Monitoring Guidelines

A dam's instrumentation furnishes data for determining if the structure is functioning as intended and continuing surveillance to warn of any unsafe developments. Monitoring physical phenomena that can lead to a dam failure may draw on a wide spectrum of instruments and procedures ranging from very simple to very complex. Any program of dam- safety instrumentation must involve proper design consistent with other project components. The program must be based on prevailing geotechnical conditions at the dam, and must include consideration of the hydrologic and hydraulic factors present before and after the project is in operation. Instrumentation designed for monitoring potential deficiencies at existing dams must take into account the threat to life and property that the dam presents. Thus, the extent and nature of the instrumentation depends not only on the complexity of the dam and the size of the reservoir, but also on the potential for deaths and property losses downstream.

An instrumentation program should involve instruments and evaluation methods that are as simple and straight-

forward as the project will allow. Moreover, you should make a definite commitment to a continuing monitoring program; if the program is not continuing, the installation of instruments and procedures will be wasted. Obviously, the involvement of qualified personnel in the design, installation, monitoring, and evaluation of an instrumentation system is of prime importance to the success of the program.

Instrumentation and proper monitoring and evaluation are extremely valuable in determining the performance of a dam. Specific information that instrumentation can provide includes:

- warning of a problem (i.e., settlement, movement, seepage, stability)
- definition and analysis of a problem, such as locating areas of concern
- proof that behavior is as expected
- evaluating remedial actions

Maintenance Guidelines

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 but the general public as well. The cost of a proper maintenance program is small compared to the cost of major repairs or the loss of life and property and resultant litigation. You should develop a basic maintenance program based primarily on systematic and frequent inspections. Inspections, as noted in Chapter 5, should be carried out monthly and after major floods or earthquakes. During each inspection, fill out a checklist of items requiring maintenance.

Emergency Action Plan Guidelines

History has shown that dams sometimes fail and that often these failures cause loss of life, injuries and extensive property damage. You should prepare for this possibility by developing an emergency action plan which provides a systematic means to:

- Identify potential problems that could threaten a dam.
- Determine who would be at risk should a failure occur.
- Expedite effective response actions to prevent failure.
- Develop a notification plan for evacuating people to reduce loss of life and property damage should failure occur.

You are responsible for preparing a plan covering these measures and listing actions that you and operating personnel should take. You should be familiar with the local government officials and agencies responsible for warning and evacuating the public.

It is important that you make full use of others who are concerned with dam safety. Emergency plans will be more effective if they integrate the actions of others who can expedite response. People and organizations with whom you should consult in preparing an emergency action plan include numerous local participants, state and federal agencies.

An essential part of the emergency action plan is a list of agencies and persons to be notified in the event of a potential failure. Possible inclusions for this list should be obtained from and coordinated with local law-enforcement agencies and local disaster emergency services—key institutions that can activate public warning and evacuation procedures or that might be able to assist you, the dam owner, in delaying or preventing failure.

Certain key elements must be included in every notification plan. Information about potential inundation (flooding) areas and travel times for the breach (flood) wave is essential. Inundation maps are especially useful in local warning and evacuation planning, including identifying evacuation routes. Detailed information about identification of inundation areas or the development of maps can be found by contacting the Texas Commission on Environmental Quality.

Operation Plan Guidelines

Establishing an operation procedure or plan calls for detailed:

- data on the physical characteristics of dam and reservoir
- descriptions of dam components
- operating instructions for operable mechanisms
- instructions for inspections
- instrumentation and monitoring guidelines
- guidelines for maintenance
- guidelines for emergency operations
- bibliographic references

Establish a schedule for both day-to-day tasks and tasks performed less frequently throughout the year. The schedule should formalize inspection and maintenance procedures so that even an inexperienced person can determine when a task is to be done.

Measures to Reduce the Consequences of Dam Failure

Liabilities that are determined following a dam failure strongly affect organizations and individuals, govern-

ments and dam owners alike. Establishing liability is the legal means developed by society to recover damages due to a wrong (in this case, lack of dam safety) and represents another perspective on the dam-safety problem. A thorough understanding of this legal process can help you decide the steps necessary to reduce liability.

You can directly and indirectly influence the introduction and use of a variety of other measures that will serve to reduce the consequences of dam failure. For example, insurance against the costs that will accrue after a failure will save you money by spreading costs to multiple dam owners. Some land-use measures instituted by governments represent better means of mitigating future disasters. Restrictions against living in inundation zones radically improve safety. Land-use measures are among the most effective ways to save lives and preserve property over the long term, but such steps are not always acceptable to governments. Thus, given that lives and property are at stake, increasing public awareness and governmental planning are vital measures that also must be considered as ways to reduce the consequences of dam failure.

You can obtain insurance directly and should do so. Other measures discussed here—land use, public awareness, and preparedness planning—are essentially controlled by local governments. You would be wise to encourage actions in the public sector that increase awareness of dam safety issues. Finally, you may also wish to hire private consultants when information needed for prudent decisions exceeds your own expertise.



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