ASDSO Program of Study

Continuing Education Guidance for Dam Safety Professionals

12/1/19

ASDSO DAM SAFETY PROGRAM OF STUDY

BACKGROUND AND PURPOSE

The ASDSO Dam Safety Program of Study was created as a roadmap for educating those working in the dam safety engineering community. Its current form is the result of many meetings, workshops and summits where experts determined what areas of education were necessary for dam safety engineers, dam safety regulators and others to practice effectively.

The current Program of Study includes 17 topic areas. This guidebook provides a description of each topic area and a listing of current ASDSO classroom courses and webinars available within those areas. It also includes a listing of corresponding national guidelines and best practices documents. It is continually updated by the ASDSO Training Committee and staff.

ASDSO is committed to working with the National Dam Safety Program, other related federal agencies and other associations to encourage coordination between dam safety, emergency management, and floodplain management officials. Several opportunities have been identified via the ASDSO training program, including assisting with the Dams 101 for Emergency Managers course, developing dam safety-related training modules for CRS participants, and creating a workshop on emergency action planning/emergency action plan exercises for dam owners, regulators, and emergency managers. This idea of balancing state-of-the-art technical training with practical, educational and awareness opportunities for the broad community of risk managers is inherent in the ASDSO Program of Study, thus making it a valuable tool for wide-spread use.

Dam Owners: The ASDSO Dam Owner Outreach Committee has researched and recommends that a series of recorded videos focused on the education needs of owners/operators of small- to medium-sized dams should be created. This accompanies the existing program that ASDSO maintains to provide "canned" one-day, face-to-face dam owner workshops. A project plan for the new video series is included here.

Contents

KEY TOPICS IN THE PRACTICE OF DAM SAFETY

PROGRAM OF STUDY TOPIC DESCRIPTION AND SUGGESTED PROFICIENCIES NEEDED

AWARENESS

Dam safety professionals, regulators and owners in particular, need to understand how to communicate the risk associated with dams to policymakers and the public.

Topic areas include:

- Public Safety at Dams
- General Awareness of Dams – Generating Awareness

CONSTRUCTION MANAGEMENT

Construction management is the study and practice of the managerial and technological aspects of construction. Construction managers serve as construction consultants, providing both design and construction advice. They deal with people, money, time, and quality of work, and must possess a combination of engineering, management, technology, business and legal skills to ensure that people keep their promises, all while nobody gets hurt, in order to build something that people need or want.

In practice, the construction management professional:

- Defines the responsibilities and structure of the organizations involved in the project,
- Organizes and leads by implementing project controls to document the project,
- Assigns roles and develops lines of communication, to build the project, and
- Manages risk by identifying project design & construction elements that could give rise to legal action.

Pre-construction job functions include:

- Bid Phase services - review of bid documents, notice of award, notice to proceed
- Constructability review
- Value engineering
- Project document review
- Permit review
- Project execution plan
- Management information system
- Pre-construction job conference

During construction, construction managers deal with:

- Project coordination
- Construction oversight (plans & specifications)
- Regular progress meetings
- Quality assurance
- Maintain project records
- Resolution of issues - change orders, requests for information
- Pay estimates - verification of work performed
- Process shop drawings / submittals
- Substantial & final completion

Post construction duties include:

- Start-up & commissioning assistance
- Operations & maintenance manuals
- Operator training
- Occupancy schedule

- Record documentation
- Warranty
- Administrative close-out

Proficiencies:

Responsibilities of a construction manager include project management planning, cost management, time management, quality management, contract administration, and safety management.

Construction inspection requires knowledge of subgrade evaluation, soils classification and placement criteria and techniques, concrete mix and placement testing, RCC, various types of pipe installation, E&S, instrumentation, gates and valves, and regulatory requirements of various agencies.

DAM SAFETY PROGRAM MANAGEMENT

Dam safety programs are organized efforts to assure that dams will be safe for continued operation. They help to protect property and people from the disastrous effects of avoidable dam incidents and failures and in establishing emergency procedures for unforeseen occurrences.

Both dam owners and regulators operate dam safety programs. Dam owners' safety programs include the financial responsibility for operation, maintenance, and correction of deficiencies. Dams that are monitored by owners will typically also be within the inventory of the agency(s) responsible for their regulation. Dam safety programs of regulatory agencies address compliance with established dam safety statutes, rules, and regulations. Both types of programs help to protect people and property from the disastrous effects of dam accidents and failures and in establishing emergency procedures for unforeseen occurrences.

Dam safety programs can be of varying size, depending primarily on the number of dams within the inventory of an owner or regulator. Smaller programs typically have owners/operators that are:

- Individuals
- Local governments
- Water companies
- Homeowners' associations
- Recreational groups
- Special purpose districts, such as watershed or irrigation districts, and
- Mining companies

Larger programs typically have owners/operators that are:

- Governmental agencies (federal or state)
- Water supply agencies or companies
- Power generating utilities
- Irrigation districts

The goals of a Dam Safety Program are to help owners/operators and regulators to:

- Prevent accidents and failures at dams. This includes advance planning for emergencies.
- Detect and correct dam safety deficiencies. This involves inspections, investigations, and analysis to allow deficiencies to be recognized and remedies made.
- Protect investments.
- Meet legal obligations.

To be proficient in this area one needs to understand and/or have experience in:

- Public and media relations
- Owner's dam safety programs
  - Lessons learned from dam failure case histories
  - Dam owner training
  - Teaching owners how to design and implement EAPs

- Regulatory dam safety programs
    - Review of consultant dam safety inspection reports and analysis
    - Technical & regulatory review of plans & specifications for dams
- Construction management: Construction inspection requires knowledge of subgrade evaluation, soils classification and placement criteria and techniques, concrete mix and placement testing, RCC, various types of pipe installation, E&S, instrumentation, gates and valves, and regulatory requirements of various agencies.

EMERGENCY ACTION PLANNING AND MANAGEMENT

Since the early days of dam construction, loss of life and damages to property have persisted as inherent risks. Underestimation of these risks and breakdowns in communication can significantly exacerbate the adverse consequences of dam failures.

Having effective Emergency Action Plans (EAPs) at all high- and significant-hazard potential dams is critical to reducing the risks of loss of life and property damage from dam failures. EAPs are especially critical at high-hazard potential dams that have been found to be deficient or do not meet current accepted dam safety criteria.

Dam owners develop EAPs to guide their responses to dam emergencies. Owners of high- or significant-hazard potential dams have an obligation to engage in the emergency planning process and to periodically exercise their EAPs in collaboration with all entities involved, including local officials, emergency management agencies, and others. EAPs that are exercised regularly will reflect the best response that dam owners and emergency management agencies can provide in the event of a dam emergency.

Proficiencies

To be proficient in this area one needs to understand and/or have experience in:

- Developing Emergency Action Plans including creating inundation/evacuation maps
- Assessing Dam Emergency Preparedness
- Exercising Emergency Action Plans
- Coordinating with Emergency Management Agencies

ENVIRONMENTAL INCLUDING REMOVAL AND TAILINGS DAMS

Working with dams requires working in and around water and wetlands, which are regulated activities. Regulation can occur at the federal, state and local level. The resources below are aimed at helping you recognize when permits are required for maintenance, rehabilitation, construction or demolition of dams. Other environmental requirements may include environmental assessments, alternative analyses, National Pollutant Discharge Elimination System (NPDES) permits, and erosion and sedimentation control permits.

Proficiencies

- Wetlands: Hydrophytic Plants; Wetland Hydrology; Hydric Soils; Wetland Delineation
- Impacts to: Wetlands/Waters; Threatened/Endangered Species; Historical/Archaeological Resources
- Permitting: Section 404 of the Clean Water Act; US Army Corps of Engineers Nationwide Permits; State Permitting for wetland/water impacts; National Pollutant Discharge Elimination System (NPDES) Permits
- Mitigation: Compensatory Mitigation Requirements; Mitigation Banking

<u>Dam Removal</u>. Throughout U.S. history, dams have provided a variety of benefits, including hydropower; navigation; recreation; water supply for domestic, industrial, and agricultural use; and other useful purposes to our society. Most dams in the U.S. were built more than half a century ago and many have outlived their initial planned purposes. As dams age, they require increasingly extensive and expensive maintenance and/or rehabilitation; continue to impose adverse environmental impacts on upstream and downstream aquatic ecosystems; present potential safety impacts to the public residing downstream or recreating in the vicinity of the dam; and continue to be a liability to dam owners. Many

public and private dam owners throughout the nation are faced with the difficult choice between undertaking costly dam upgrades or opting for a typically less expensive - though not necessarily less complex - option of dam removal. Weighing the costs and benefits of each option can be a highly complex task.

Proficiencies

To be proficient in this area one needs to understand and/or have experience in:

- Safety inspections for existing dams
- Regulatory processes involved in the rehabilitation or removal of a dam
- Watershed planning
- Community/business/personal dam-related decision making
- Ability to thoroughly assess and understand a dam's environmental, economic, and social benefits and impacts
- Consideration of community values as they relate to the dam and upstream impoundment
- Public communications

Tailings. Tailings dams are structures built to impound mining waste and the term has also been used to describe impoundments for other industrial by-products. These waste and by-products, often referred to as slimes, tails, leach residue, slickens or ash, are generally fine sized particles mixed with water and sluiced to the impoundment for disposal. The slurry typically remains saturated during operation of the impoundment and may remain so indefinitely after operation ceases. Most tailings contain environmental contaminates which may be naturally occurring minerals and compounds or additives to facilitate the mining and industrial processes. These contaminates may be released from the impoundment via modes other than embankment failure and they retain their hazard potential in perpetuity.

There has been an increase in the size of tailings dams, with some now ranked among the largest dams in the world. While the methods used for the design and construction of tailings dams are similar to typical embankment dams, tailings dams are required for the storage of unwanted by-products, desirably at minimum cost. Accordingly, construction may be completed in phases over many years with multiple changes in engineers, supervisors or ownership. This phased construction requires unique spillway designs and may incorporate unconventional embankment construction methods with either soil or waste material. Additionally, long term, low cost maintenance solutions should be addressed in the design process.

Proficiencies

- Geotechnical/seismic investigations and analysis
- Liner systems (clay or geosynthetic)
- Hydrogeology (groundwater modeling and monitoring)
- Environmental regulations (water treatment facility; landfill facility)
- Dam safety regulations
- Spillway hydraulics & structural design
- Liquefaction potential of slurry (non-newtonian fluids properties; insitu testing of tailings [shear vane])
- Dam break analyses (hydraulic modeling (for initial water filled impoundment); slurry flow modeling (for slurry filled impoundment)
- Emergency action plans
- Embankment construction methods and sequencing (upstream facing; downstream facing)
- Closure/abandonment procedures and plans

FAILURE INVESTIGATIONS

Dam failures are usually tragic events. Competent and independent investigations serve the following purposes:

- To determine the cause(s) of failure
- To understand contributing factors including organizational and cultural factors.
- To learn what went right and recognize efforts/successes
- To better support communication with the public and the press
- To identify lessons learned
- To recognize deficiencies and advance design/construction practices
- To improve understanding of warning signs of dam distress
- To improve dam safety regulation and dam engineering
- To prevent future failures
- To increase awareness of dam safety and civil infrastructure

Proficiencies:

TBD

GEOTECHNICAL

Geotechnical engineering and the related discipline of engineering geology are critical to dam safety and dam engineering. These disciplines encompass understanding and evaluation of soil and rock foundation materials for all types of dams and embankment materials for earthfill and rockfill dams. Issues to be addressed for soil and rock materials can be broadly characterized as strength, deformability, and permeability.

Proficiencies

The activities involved in geotechnical engineering and engineering geology for dam safety and dam engineering are numerous and include:

- Field investigations, both surface and subsurface,
- In-situ testing, including geophysics,
- Laboratory testing, including evaluation of index properties and engineering properties,
- Stability analysis,
- Seepage analysis, including consideration of internal erosion potential,
- Settlement and deformation analysis,
- Structure foundation support evaluation,
- Specifications for embankment materials,
- Quality control and quality assurance during construction.

HYDROLOGY AND HYDRAULICS

Hydrology is one of the earth sciences and encompasses the occurrence, distribution, movement, and properties of waters of the earth. For dams, the most relevant subset of the science of hydrology is surface water hydrology, which is most often used in dam engineering for estimating flood inflows to the dam and reservoir. Dams are to be designed to be capable of passing large floods; estimating the magnitude of these floods is critical to dam safety.

Floods typically evaluated in dam engineering include frequency-based storms (e.g. 1-year through 500-year flood) and the Probable Maximum Flood (PMF), which is developed based upon the Probable Maximum Precipitation (PMP). The PMP is the greatest depth (amount) of precipitation, for a given storm duration, that is theoretically possible for a particular area and geographic location. The PMF is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area.

Dams are designed or required to safely pass what is typically termed the Spillway Design Flood (SDF) or Inflow Design Flood (IDF), which typically ranges from the 100-year flood to the PMF. The selection of an SDF or IDF is usually based on the hazard category of the dam and the potential for loss of life or property damage that would result from a dam failure during a given flood.

Hydrologic analysis for estimating the SDF or IDF for dams includes:

- Delineation of the watershed contributing to the dam
- Developing theoretical precipitation amounts and distribution over the storm duration
- Estimating infiltration to compute runoff volume
- Computing runoff distribution based upon a synthetic hydrograph theory
- Storage routing of the inflow through the impounding body (lake, reservoir, etc.)

In addition to estimating the SDF or IDF, hydrology for dam projects could include evaluation of flood protection provided by the structure. Also, many dams provide water supply and the hydrologic analysis for these structures could extend to drought hydrology for sizing reservoirs and defining releases to address environmental concerns.

Hydrologic analyses range from simplified equations and methods to complex computer models, including commonly used models developed by the US Army Corps of Engineers (USACE) and Natural Resources Conservation Service (NRCS). Geographic Information Systems (GIS) have helped engineers and scientists develop watershed parameters more quickly and accurately.

Individuals interested in hydrologic analysis for dams should develop an understanding of the hydrologic cycle and flood events and should be proficient in reading topographic maps and computer models such as the USACE HEC-HMS and NRCS SITES programs. An understanding of GIS is also recommended.

Proficiencies

- Basic Hydrology for Dams
- Meteorology and Rainfall Frequency
    - Precipitation – Formation, types, losses
    - Precipitation – Frequency estimates
    - PMP Theory and Studies
    - GIS-based Methods for Precipitation Estimates
    - Probability of Extreme Events
- Precipitation Distribution Modeling
    - Methods for precipitation distribution
    - PMP distributions
    - Site-specific PMP analyses
    - GIS-based methods for precipitation distribution
- Watershed Modeling
    - Components of the runoff hydrograph, unit-hydrograph theory and application
    - Stream gage flood frequency analysis
    - Empirical hydrologic estimation methods and model calibration
    - GIS-based methods for watershed modeling

Hydraulics is the branch of engineering related to the behavior of fluids. For dams, the parameters of interest include discharge (or flow) rate, velocity, pressure, duration, and depth of flowing water and how these parameters impact the performance of the structures of the dam. Hydraulics for dams is often considered complementary to hydrology.

Hydraulic structures at dams can be divided into spillways and outlet works. Spillways are typically designed to pass normal and flood flows while outlet works are used to discharge water to supply lines for drinking water or to facilities used to produce hydropower. Outlet works are also often used to lower or drain the impoundment.

The spillway or system of spillways at a dam should be designed to safely pass the required Spillway Design Flood (SDF) or Inflow Design Flood (IDF). Types of spillways include:

- Riser (tower) and conduits
- Channels excavated into earth or rock
- Straight overflow weirs of various shapes (broad and sharp crested, ogee)
- Overflow weirs with more complex plan forms (box spillways, duckbill weirs, labyrinth weirs)
- Side channel spillways
- Gated overflow spillways

Spillways and outlet works are divided into several components, listed below in order of the direction of flow:

- Entrance channel
- Intake structure
- Control section (may be part of intake structure)
- Conveyance structure
- Energy dissipator
- Exit channel

The analysis and design for each of these components involves estimating the hydraulic properties of water as it passes over and through the element. The performance of hydraulic structures can be evaluated using physical and/or numerical models (i.e. computational fluid dynamics). Numerous methods for the analysis of hydraulic structures have been developed, primarily based on extensive modeling performed by agencies such as the US Army Corps of Engineers, Bureau of Reclamation, and Natural Resources Conservation Service.

Hydraulic analysis required for dams also includes the modeling of a failure (or breach) of the structure and resulting downstream flooding. Dam breach and downstream inundation analyses and mapping are used to assign hazard category, develop the SDF/IDF, and estimate flooding for use in development of emergency action plans (EAPs). This analysis requires knowledge of the mechanics of dam failures and open channel flow.

Individuals interested in hydraulic analysis for dams should develop a strong understanding of fluid mechanics and open channel flow.

Proficiencies

- Basic hydraulics for dams
- Floodplain hydraulics: hydraulics of open channel flow; computer modeling of open channel Flow; GIS-based methods applications
- Spillway hydraulics: hydraulic design of outlet works; hydraulics of stepped spillways; hydraulics of labyrinth spillways; hydraulics, stability, and integrity of earthen and rock spillways
- Hydraulic design of stilling basins and energy dissipators
- Hydraulic design of erosion protection for channels (wave protection, etc)
- Hydraulic design of overtopping systems
- Numerical and physical modeling of spillways
- Hydraulics for conduits, valves and gates
- Reservoir and channel routing: level-pool routing theory; dynamic routing theory; computer modeling of routing through channels and reservoirs
- Dam break modeling/methodologies – steady flow theory and overview of unsteady flow theory; incremental dam breach analysis; simplified inundation mapping for emergency action plans

INSPECTION

Prior to the US Army Corps of Engineers (USACE) Phase I Inspection Program (1978-1981), dam inspections were primarily focused on new or developing conditions at a dam. Except for a few states and large federal agencies, dam inspections had little formality or frequency, and most inspection activity dealt with large dams or dams that had serious deficiencies. As part of the Phase 1 process, the USACE developed the first formal inspections process, dam classifications, and basic tools for evaluation and inspection procedures. The dam classification system (high, medium, and low-hazard potential) was based on the potential economic consequences and loss of life posed by the hypothetical failure of an individual dam. Some states—such as California, Colorado, and Pennsylvania—had regulatory authority for formal inspection programs, but most did not. The Federal Energy Regulatory Commission required private dam owners of hydropower facilities perform formal "independent" inspections of their dams every five years.

Most current inspections of dams are proactive and aim to measure the dam's performance as compared to the original design. Dam Inspections today are performed at several levels, from daily informal visual inspections to robust formal inspections requiring highly skilled and experience engineers and technical staff.

Proficiencies

To be proficient in this area one needs to understand and/or have experience in:

- Safety inspections for existing dams
- Plant and animal penetrations of dams
- Digital imaging and recording technology
- Construction inspections
- Diversion and care of water
- Introductory surveying (levels, pop levels, field measurements, etc)
- Inspection levels
- Specialty inspections (confined space entry, video/ROV, rappelling, diving, etc)
- Dam safety incident and emergency inspections

OPERATION AND MAINTENANCE

An Operation and Maintenance (O&M) Program is a systematic means of ensuring that a dam is operated and maintained adequately. Adequate operation and maintenance are critical for ensuring the continued safe operation of the dam, and the continued productive use of the dam and reservoir. An O&M Program includes the following major phases:

Planning: During the planning phase, the O&M activities to be performed are identified. The frequency of each O&M activity is determined.

Implementing: During the implementation phase, the resource requirements for performing the O&M activities are identified, and the O&M activi-ties are performed. Systems are established for monitoring and tracking O&M activities and expenditures. Finally, information is collected, and records are maintained.

Evaluation: During the evaluation phase, the O&M Program is assessed. The costs and benefits of the Program are identified. Program strengths and weaknesses are identified. The assessment infor-mation is used to plan new actions for improving the O&M Program.

To be proficient, one must know how to plan, implement and evaluate an O&M Program. Planning includes identifying activities to be performed, developing operating procedures, establishing record-keeping systems, and writing the plan. Implementation includes securing adequate resources and administration. Evaluation includes the identification of evaluation standards, the collection of data, and the assessment of the Program's effectiveness.

RISK ANALYSIS AND RISK INFORMED DECISION-MAKING

Risk, as used in the dam safety community, can be generally defined as a measure of the likelihood and severity of adverse consequences. Dam Safety risk is computed for a variety of potential failure modes, typically considering failure as an uncontrolled release of the reservoir. The risk for a failure mode is computed as the product of the:

- likelihood of a loading condition (static, seismic, hydrologic, mechanical, electrical);
- response of some component of the dam to the load (likelihood of failure given the load); and

- consequences of the dam's response to the load (consequences of dam failure).

Total risk is the summation of risk from the identified potential failure modes. Risk is expressed in terms of life-safety and economic consequences on an annualized basis. The units of measure for dam safety risk are loss-of-life per year for life-safety and costs (dollars) per year for property damages and economic losses.

Risk-informed decision-making is the process of using information about risk to assist in decision-making about a wide variety of dam safety activities. This would include decisions regarding actions such as: frequency of inspection; need for increased instrumentation; need for additional technical studies; assessment of how uncertainties affect the level of risk; sufficiency of evidence to support the need for remedial action; selection of a remedial action to address an identified deficiency; prioritization of projects or actions; and the sequence in which remedial actions are taken at a given dam or group of dams.

Quantification of risk through risk analyses is accomplished by individuals with experience in various fields such as geotechnical, hydrologic, hydraulic, structural, mechanical and electrical engineering, engineering geology, meteorology, seismicity, dam construction, project operations and other related fields as they pertain to a given potential failure mode at a specific dam. These are individuals who can provide information regarding the likelihood of a given loading condition (flood, earthquake, maximum reservoir levels, etc), or the process by which failures occur (sequence and likelihood of system responses) or the manner in which the dam and reservoir have been operated.

Decision-making is typically accomplished by individuals or groups with a broad range of technical and management experience in dam safety and project operations. Qualitative or quantitative information about dam safety risks are considered along with other project-specific information in deciding on a course of action. Risk-informed decision making can be conducted in a manner that seeks efficiency in balancing the costs of risk reduction with addressing the highest risks first.

Proficiencies:

To be proficient in this area one first needs to have experience in one or more engineering or scientific disciplines that provide information about failure modes for dams and also understand the procedures used for computation of dam safety risk. In addition, it is desirable to have dam design, analysis, and construction experience as well as knowledge in dam operations. Experience or training in the following subject areas would be beneficial:

- Procedures used for conducting Potential Failure Mode Analysis (PFMA)
- Concepts and procedures used to estimate the likelihood of static, hydrologic or seismic loading conditions
- Mechanisms by which failure occurs for various components of a dam and appurtenances
- Use of event trees for computation of risk for individual potential failure modes and estimation of total risk
- Engineering and societal perspectives on risk, risk tolerance and approaches to risk reduction

SEISMIC

Seismic considerations for dam safety include estimation of seismic hazards, analysis of expected performance during possible earthquake shaking, and design and construction to provide for safe performance during earthquakes. Potential seismic hazards include ground shaking (often represented by predicted levels of ground acceleration), fault rupture, and seiche waves. Hazards can be evaluated using either deterministic or probabilistic methods.

Earthquake analysis and earthquake-resistant design differs for embankment and concrete dams. For embankment dams, evaluations need to be completed to estimate engineering properties (strengths and deformation characteristics) applicable for earthquake loading, with due consideration to possible strength reductions, particularly strength reductions which might occur because of the phenomenon of liquefaction. Potential earthquake-induced instability or excessive deformation must be evaluated. If unacceptable earthquake performance is predicted, some methods that have been used to improve expected performance for embankment dams include in situ soil improvement, removal and replacement of weak soils, embankment buttressing and combinations of these methods.

For concrete dams, analyses need to consider the potential for earthquake loading to cause sliding, overturning, or overstressing. If unacceptable earthquake performance is predicted, some methods that have been used to improve expected performance of concrete dams include anchoring and buttressing.

Proficiencies

To be proficient in this area one needs to understand and/or have experience in:

- Earthquake Engineering for Dams
- Dynamic Seismic Analyses for Dams

SITE SECURITY

Site security focuses on the protection and resiliency of dams and levees and includes an understanding of how to identify security vulnerabilities, to assess risks to facilitates, to implement effective protective programs, and to improve incident response capabilities.

Proficiencies

To be proficient in this area one need to understand the following:

- Risk and Crisis Management: Planning and Exercising
- Security Awareness including identification of common vulnerabilities, identification of indicators of threat activities and recording/reporting suspicious activities and incidents.
- Protective Measures including proper development of physical and cyber protections and human element protections.

STRUCTURAL

Structural engineering for dams includes the application of conventional structural design and analysis for concrete arches, walls, slabs, columns, beams and so on, as well as the design and analysis of gravity structures such as the dam itself or gravity spillways, end sills, toe blocks, and buttresses. Since structural engineering is a traditional collegiate program of study, this guide focuses primarily upon the design, stabilization and repair of hydraulic mass concrete structures which are most often encountered by practitioners. Some consideration will also be given to the analysis and stabilization of arch, gravity arch, slab and buttress dams and their variants which represent a relatively small, but significant, percentage of concrete and masonry dams in the United States.

Proficiencies

To be proficient in this area one needs to understand and/or have experience in:

- Fundamentals of RCC design and construction for dams
- Fundamentals of conventional concrete design and construction for hydraulic structures (AAR evaluation for concrete structures, etc.)
- Design and rehabilitation of outlet works for dams
- Stability analyses for dams and appurtenant structures (concrete gravity dams; Ambursen dams; arch dams, etc.)
- Thermal analysis for mass concrete structures

- Repair of dam appurtenances including concrete structures, conduits, gates, valves, etc.
- Use of post-tensioned and other anchor methods for dams
- Design and analysis of spillway gates
- Design and evaluation of towers, outlets, tunnels and bridges

SURVEILLANCE AND MONITORING

Monitoring dam performance is a critical element in producing and maintaining a safe dam. Monitoring programs typically consist of; surveillance or visual observation; instrumentation; data collection; data evaluation, presentation and management; and decisions/response based on results. Surveillance and Monitoring programs on dams provide information for evaluating the dam's performance with respect to design intent and expected behavior, monitoring for changes that could affect the safe performance of the dam, to assist in investigations and evaluations of abnormal or degrading dam performance and determining if maintenance or remedial action is necessary.

Proficiencies

To be proficient in this area one needs to understand and/or have experience in:

- Basic behavior monitoring for dams
- Assessment of surveillance and monitoring requirements
- Instrument data interpretation
- Operation, use and maintenance of instrumentation
- Emerging technology
- Design and installation of instrumentation
- Dam performance monitoring

COURSES AND GUIDELINES

AWARENESS

TOPICS

1. Public Safety at Dams
2. General Awareness of Dams – Generating Awareness

CLASSROOM COURSES

None created or identified to date.

WEBINARS

1. Identifying Hazards and Improving Public Safety at Low Head Dams (Tschantz and Schweiger, 2013) - ASDSO
2. Introduction to Public Safety Risk Evaluation and Treatment for Dams and Levees (Cattanach, 2015) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

None created or identified to date.

GUIDELINES

1. Guidelines for Public Safety Around Dams (Canadian Dam Association, 2011)
2. Model State Dam Safety Program (FEMA; ASDSO, 2006)
3. Emergency Preparedness Guidelines for Levees: A Guide for Owners and Operators (DHS Dams Sector, 2012)
4. Federal Guidelines for Dam Safety Risk Management [FEMA P-1025] (FEMA, 2015)
5. Engineering and Design: Safety of Dams – Policy and Procedures [ER 1110-2-1156] (USACE, 2014)
6. Training Aids for Dam Safety: Dam Safety Awareness (FEMA)
7. Pocket Safety Guide for Dams and Impoundments (FEMA, 2016)

COURSES AND GUIDELINES

DAM SAFETY PROGRAM MANAGEMENT

TOPICS

1. Model Regulatory Programs
2. Technical and Regulatory Review of Plans and Specs
3. Lessons Learned from Dam Failures
4. Dam Failure Investigations
5. Dam Owner Education
6. Dealing with the Media
7. Human Resources Management
8. Land Use Planning (including Critical Facilities)
9. Review of Consultant Inspection Reports

CLASSROOM COURSES

1. Plans and Specifications Review and Construction Inspections for Dams, Levees and Ancillary Structures-ASDSO
2. Dam Failures and Lessons Learned - ASDSO
3. Dam Owner Workshop: The Need-to-Know Basics of Dam Ownership - ASDSO
4. Dam Owner Workshop: Engineering for Non-Engineers-ASDSO
5. Dam Owner Workshop: Operation & Maintenance for Dam Owners-ASDSO

WEBINARS

1. Human Factors in Dam Failure and Safety (Alvi, 2015) - ASDSO
2. Significant Dam Failures Webinar Series: - ASDSO
    a. The Fontenelle Dam Incident 1965 (Baker, 2017)
    b. Reexamination of the 2004 Big Bay Dam, Mississippi
3. Findings of the Oroville Dam Spillway Forensic Investigation (France 2018) - ASDSO
4. Findings of the Oroville Dam Spillway Forensic Investigation Part 2: Human Factors (Alvi 2018) - ASDSO
5. Development of Operations and Maintenance Manuals for Dams (Jamieson 2014) - ASDSO
6. Spillway Conduits – More Than Just a Pipe Through the Dam (Monroe, 2016)-ASDSO
7. Dam Owner Webinar: Intro to Inspecting Dams for Owners and Operators (Schweiger 2013) - ASDSO
8. Dam Owner Webinar: Emergency Intervention Toolbox (Aulenbach & Schweiger 2018) - ASDSO
9. Emergency Action Plan Basics (France, 2012) - ASDSO
10. How to Make Your Emergency Action Plan More Effective (McCormick, Jamieson, Kimble, 2017) - ASDSO
11. Legal Responsibilities of Dam Owners, Operators, and Regulators (Binder, 2013) - ASDSO
12. How to Communicate Effectively in Any Situation (Greenberger, 2014) - ASDSO
13. 2018 Risk Communication for Dams (Mullen, 2018) - ASDSO
14. NRCS Dam Design and Dam Safety Resources: Policy, Procedures & Tools (Durgin, 2017) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

None created or identified to date.

GUIDELINES

1. Model State Dam Safety Program (FEMA; ASDSO, 2006)
2. Safety Evaluation of Existing Dams: A Manual for the Safety Evaluation of Embankment and Concrete Dams (USBR, 2000)
3. National Engineering Handbook, Part 642 - Specification for Construction Contracts [H.210.NEH.642] (NRCS, 2015)
4. National Operation and Maintenance Manual (NRCS, 2003)
5. Low Hazard Dams Standard Operating Procedures (U.S. Fish & Wildlife Service, 2008)
6. Dam Failures Investigation Guideline (ASDSO, 2011)
7. * Lessons from Dam Incidents, USA (ICOLD, 1975)
8. * Lessons from Dam Incidents, USA-II (ICOLD, 1988)
9. * Failure of Teton Dam, Final Report (US Department of the Interior, 1980)
10. * Independent Forensic Team Report Oroville Dam Spillway Incident (ASDSO; USSD, 2018)

* Reports related to lessons learned from dam failures, include recommendations

EMERGENCY ACTION PLANNING AND MANAGEMENT

TOPICS

1. Intro to Interactive Preparedness and Emergency Action Planning
2. EMI Courses: IS100, 200, 300, 700, 800; IS890, 891, 892; E775
3. EAP Exercise Design
4. Potential Failure Mode Analysis: Basic and Advanced
5. ICS, NIMS, NRF, EOC Operation
6. Lessons Learned from Dam Failures

CLASSROOM COURSES

Interactive Preparedness: Emergency Action Planning for Dams and Levees

WEBINARS

1. Emergency Action Plan Basics (France, 2012) - ASDSO
2. How to Make Your Emergency Action Plan More Effective (McCormick, Jamieson, Kimble, 2017) - ASDSO
3. Intro to Potential Failure Modes Analysis (Boyer, 2014) - ASDSO
4. Applications of PFMA in Dam Safety (Boyer, 2014) - ASDSO
5. PFMA Dos and Don'ts/Lessons Learned (Boyer 2018) - ASDSO
6. The Fontenelle Dam Incident 1965 (Baker 2017) - ASDSO
7. Findings of the Oroville Dam Spillway Forensic Investigation (France 2018) - ASDSO
8. Lawn Lake Dam: Pre-Failure Comprehensive Dam Safety Evaluation and Post Failure Impacts (McCormick & Baker 2019) - ASDSO
9. Lessons Learned Regarding Seismic Deformation Analyses of Embankment Dams from Re-Evaluation of the Upper and Lower San Fernando Dams Performance Case Histories (Seed & Chowdhury 2019) - ASDSO
10. Explosive Phenomenology and Blasting Near Dams (Hossley & Rickman 2019) - ASDSO
11. WinDAM - Overtopping and Internal Erosion for Earthen Embankments (Visser & Fripp 2019) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

Self-paced or classroom courses that relate to dam safety management on IS100, 200, 300, 700, 800, IS890, 891, 892, E775. Always in FEMA courses.

Self-paced or classroom courses that relate to dam safety management on Integrated Emergency Management. Taught by FEMA

Self-paced or classroom courses that relate to dam safety management on ICS, NIMS, NRF, EOC Operation. Taught by FEMA.

GUIDELINES

1. Engineering Guidelines for the Evaluation of Hydropower Projects Chapter 6 – Emergency Action Plans (FERC, 2015)
2. Dam Safety – An Owners Guidance Manual [FEMA 145] (FEMA, 1987)

3. Federal Guidelines for Dam Safety – Emergency Action Planning for Dams [FEMA 64] (FEMA, 2013)
4. Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures [FEMA P-946] (FEMA, 2013)
5. A Guide to Public Alerts and Warnings for Dam and Levee Emergencies (USACE, 2015)
6. Engineering and Design: Safety of Dams - Policy and Procedure [ER 1110-2-1156] (USACE, 2014)
7. Safety Evaluation of Existing Dams: A Manual for the Safety Evaluation of Embankment and Concrete Dams (USBR, 2000)
8. Low Hazard Dams Standard Operating Procedures (U.S. Fish & Wildlife Service, 2008)
9. Federal Guidelines for Dam Safety: Hazard Potential Classification Systems for Dams [FEMA 333] (FEMA, 2004)
10. Developing Emergency Action Plans Using the NRCE Sample EAP "Fillable Form" Template (NRCS; ASDSO, 2007)
11. Emergency Preparedness Guidelines for Levees: A Guide for Owners and Operators (DHS, 2012)
12. Dam Failures Investigation Guideline (ASDSO, 2011)
13. * Lessons from Dam Incidents, USA (ICOLD, 1975)
14. * Lessons from Dam Incidents, USA-II (ICOLD, 1988)
15. * Failure of Teton Dam, Final Report (US Department of the Interior, 1980)
16. * Independent Forensic Team Report Oroville Dam Spillway Incident (ASDSO; USSD, 2018)

* Reports related to lessons learned from dam failures, include recommendations

ENVIRONMENTAL

TOPICS

1. Dam Decommissioning
2. Tailings Dams
3. Dams and: NEPA, CEQA, Section 106 of NHPA, Endangered Species, Hazardous Materials, Wetlands Impacts
4. Fish Passage
5. Instream Flows

CLASSROOM COURSES

None created or identified to date.

WEBINARS

1. Intro to Dam Decommissioning (Schweiger, 2016) - ASDSO
2. Intro to Tailings Dam and Coal Ash Impoundment Design, Construction and Monitoring: Current Practice (Davidson and Winckler, 2016) - ASDSO
3. Intro to Nature-Like Fishways for Dams (Aadland, 2017) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

None created or identified to date.

GUIDELINES

1. US Army Corps of Engineers Nationwide Permits (USACE, 2017)
2. Corps of Engineers Wetland Delineation Manual (USACE. 1987)
3. Effects of Riprap on Riverine and Riparian Ecosystems [ERDC/EL TR-03-4] (USACE, 2003) Report
4. Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures [ETL 1110-2-583] (USACE, 2014)
5. Design of Small Dams (USBR, 1987)
6. National Engineering Handbook Part 654: Stream Restoration Design (NRCS, 2007)
7. Field Indicators of Hydric Soils in the United States (USDA, 2018)
8. Field Book for Describing and Sampling Soils (USDA, 2012)
9. Model Mitigation Plan Checklist (USACE; US EPA, 2003)
10. Wetlands Compensatory Mitigation Factsheet (US EPA)
11. NPDES Permit Writers' Manual (US EPA, 2010)
12. Water Resources Engineering: Handbook of Essential Methods and Design (A. Prakash; ASCE, 2004)
13. Dams and Cultural Heritage Management (World Commission on Dams, 2000) Report
14. Impacts of Animals on Earthen Dams [FEMA 473] (FEMA, 2005)
15. Impacts of Plants on Earthen Dams [FEMA 534] (FEMA, 2005)

Tailings

1. Engineering and Design Manual: Coal Refuse Disposal Facilities (Mining Safety and Health Administration, 2010)
2. Design and Evaluations of Tailings Dams [EPA 530-R-94-038] (US EPA – 1994) Report
3. Tailings Dams: Risk of Dangerous Occurrences: Lessons Learnt from Practical Experiences (ICOLD, 2001)
4. Monitoring of Tailings Dams. Review and Recommendations (ICOLD, 1996)
5. A Guide to Tailings Dams and Impoundments: Design, Construction, Use and Rehabilitation (ICOLD, 1996)
6. Sustainable design and post-closure performance of tailings dams [ICOLD Bulletin 153] (ICOLD, 2013)
7. Improving tailings dam safety - Critical aspects of management, design, operation and closure [ICOLD Bulletin 139] (ICOLD, 2011)

Dam Removal

1. US Fish and Wildlife Service Low Hazard Dams (US FWS, 2015)
2. Guidelines for Dam Decommissioning Projects (USSD, 2015)
3. Frequently Asked Questions on the Removal of Obsolete Dams (US EAP, 2016)
4. A Function-Based Framework for Stream Assessment and Restoration Projects [EPA 843-K-12-006] (US EPA, 2012)
5. Guidelines for Public Safety Around Dams (Canadian Dam Association, 2011)

GEOTECHNICAL

TOPICS

1. SEED
2. Soil Mechanics – Basic and Advanced
3. Slope Stability Analysis of Embankment Dams – Basic and Advanced
4. Geotechnical Review of Embankment Dams
5. Internal Erosion and Piping
6. Engineering Geology for Dam Safety
7. Repairing Seepage Problems, Slides and Sinkholes
8. Seepage and Piping of Earthen Dams
9. Treatment and Grouting of Foundations
10. Dynamic Analysis for Embankment Dams

CLASSROOM COURSES

1. Soil Mechanics for Dam Safety - ASDSO
2. Slope Stability Analysis of Embankment Dams - ASDSO
3. Seepage for Earth Dams - ASDSO

WEBINARS

1. Guidelines for Assigning Erodibility Parameters to Soil Horizons for SITES Analysis (McCook, 2010) - ASDSO
2. Pitfalls in Quality Control Processes for Compacted Earthfill (McCook, 2010) - ASDSO
3. Designing Slope Protection for Dams and Levees (Weggel, 2015) - ASDSO
4. Strength Selection for Static Slope Stability Analysis (France and Winckler, 2016) - ASDSO
5. Empirical Estimates of Permeability for Earth Dam Projects (McCook, 2010) - ASDSO
6. 3D Effects on Estimation of Gradients, Seepage Flows, and Eval of Internal Erosion Potential Failure Modes (Ferguson, 2016) - ASDSO
7. Seepage Monitoring and Analysis of Embankment Dams (Pabst 2014) - ASDSO
8. The Practical Use of Geophysics to Assess Dam and Levee Safety (Lee and Burch 2016) - ASDSO
9. Introduction to Embankment Dams (France 2017) - ASDSO
10. Filter Design History and a One-Step Process (McCook and Talbot, 2011) - ASDSO
11. Introduction to Grouting for Dams (Wilson, 2012) - ASDSO
12. Seepage Rehabilitation for Embankment Dams (France and Williams, 2015) - ASDSO
13. Cracking and Hydraulic Fracturing in Embankment Dams and Levees (Miller, 2016) - ASDSO
14. Introduction to Embankment Dams (France, 2017) - ASDSO
15. Why Embankments Crack and How to Fix Them (Doerge 2018) - ASDSO
16. Evaluation and Maintenance of Piezometers, Relief Wells, and Drains in Dams and Levees (Easton & Springer 2018) - ASDSO
17. Managing Increased Dam Safety Risk During Reconstruction (Williams & Shannon 2018) - ASDSO
18. Advances in Geologic Data Collection and 3D Geologic Modeling for Site Characterization and Safety Studies (Cannon, Rogers, Snider, Nuyda, 2017) - ASDSO
19. Introduction to Internal Drainage Systems for Dams (Talbot, 2013) - ASDSO

20. Evaluation of Seepage Related Potential Failure Modes (PFM's) in Embankments with Emphasis on Outlet Penetrations (Ferguson, 2013) - ASDSO
21. Underwater Installation of Geomembranes (Wilkes, 2017) - ASDSO
22. Introduction to Grouting for Dams (Wilson, 2012) - ASDSO
23. Foundation Cutoff Walls for Dams and Levees (Bruce, 2016) - ASDSO
24. Internal Erosion – Applying Erosion Mechanics From ICOLD Bulletin 164 In Internal Erosion Failure Mode Analyses (Bridle & France 2019) - ASDSO
25. Lawn Lake Dam: Pre-Failure Comprehensive Dam Safety Evaluation and Post Failure Impacts (McCormick & Baker 2019) - ASDSO
26. Intro to Post-Tensioned Anchors for Dams (Bruce 2019) - ASDSO
27. Lessons Learned Regarding Seismic Deformation Analyses of Embankment Dams from Re-Evaluation of the Upper and Lower San Fernando Dams Performance Case Histories (Seed & Chowdhury 2019) - ASDSO
28. Dam Overtopping Protection Systems – Part I (Hepler 2019) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

Training Aids for Dam Safety: Evaluation of Seepage Conditions -FEMA

GUIDELINES

1. Engineering Guidelines for the Evaluation of Hydropower Projects: Chapter 4 - Embankment Dam (FERC, 2006)
2. Engineering Guidelines for the Evaluation of Hydropower Projects: Chapter 5 - Geotechnical Investigations and Studies (FERC, 1991)
3. Guidelines for Drilling In and Near Embankment Dams and their Foundations (FERC, 2016)
4. Evaluation and Monitoring of Seepage and Internal Erosion [FEMA P-1032] (FEMA, 2015)
5. Filters for Embankment Dams - Best Practices for Design and Construction (FEMA, 2011)
6. Engineering and Design: Seepage Analysis and Control for Dams [EM 1110-2-1901] (USACE, 1993)
7. Geophysical Exploration for Engineering and Environmental Investigations [EM 1110-1-1802] (USACE, 1995)
8. Geotechnical Investigations [EM 1110-1-1804] (USACE, 2001)
9. Geotechnical Reliability of Dam and Levee Embankments (USACE; T.F. Wolff; A. Hassan; R. Khan; I. Ur-Rasul; M. Miller, 2004)
10. Slope Stability [EM 1110-2-1902] (USACE, 2003)
11. Design Standards No. 13, Embankment dams Chapter 16 - Cutoff Walls (USBR, 2014)
12. Design Standards No. 13, Embankment dams Chapter 12 - Foundation and Earth Material Investigation (USBR, 2012)
13. Design Standards No. 13, Embankment dams Chapter 20 – Geomembranes (USBR, 2014)
14. Design Standards No. 13, Embankment dams Chapter 19 – Geotextiles (USBR, 2014)
15. Design Standards No. 13, Embankment dams Chapter 17 - Soil-Cement Slope Protection (USBR, 2013)
16. Design Standards No. 13, Embankment dams Chapter 4 - Static Stability Analyses (USBR, 2011)
17. Earth Manual Part 1 (USBR, 1998)
18. Engineering Geology Field Manual (USBR, 2001)

19. Ground Water Manual: A Guide for the Investigation, Development, and Management of Ground-Water Resources (USBR, 1995)
20. Design of Small Dams (USBR, 1987)
21. National Engineering Handbook Section 8 - Engineering Geology (NRCS, 1978)
22. National Engineering Handbook Part 628, Chapter 51 - Earth Spillway Erosion Model (NRCS, 2014)
23. National Engineering Handbook Part 633, Chapter 26 - Gradation Design of Sand and Gravel Filters (NRCS, 2017)
24. National Engineering Handbook Part 650 Chapter 4 - Elementary Soil Engineering (NRCS, 1990)
25. National Engineering Handbook Part 631, Geology - Rock Material Field Classification System (NRCS, 2002)
26. National Engineering Handbook Part 628 Chapter 45 - Filter Diaphragms (NRCS, 2007)
27. Geotechnical and Foundation Engineering Module 1 - Subsurface Investigations (US Department of Transportation Federal Highway Administration, 1997)
28. Internal Erosion of Existing Dams, Levees and Dikes, and their Foundations (ICOLD, 2017)

HYDROLOGY & HYDRAULICS

TOPICS

1. Dam Failure Analysis
2. Hydraulic Analysis of Spillways
3. Conduits, Valves and Gates
4. Hydraulics for Dams – Basic and Advanced
5. Hydrology for Dams – Basic and Advanced
6. Dam Break Modeling: Methodologies, Incremental Dam Breach Analysis, Simplified Dam Breach Analysis
7. HEC-HMS and HEC-RAS
8. Watershed Modeling
9. Spillway Hydraulics
10. Floodplain Hydraulics
11. Design of Stilling Basins and Energy Dissipators
12. Design of Erosion Protection for Channels
13. Design of Overtopping Systems
14. Numerical and Physical Modeling of Spillways
15. Reservoir and Channel Routing
16. Meteorology and Rainfall Frequency
17. Precipitation Distribution Modeling

CLASSROOM COURSES

1. HEC-HMS – Basic -- ASDSO
2. HEC-RAS with and Intro to HEC-RAS 2-D (Basic) -- ASDSO
3. Conduits, Valves & Gates -- ASDSO

WEBINARS

1. Hydrology 101; Intro to Hydrology for Dam Safety (Miller, 2011) - ASDSO
2. Hydrology 201 for Dam Safety (Miller, 2012) - ASDSO
3. Hydraulics 101: Intro to Hydraulics for Dam Safety (Miller, 2011) - ASDSO
4. Hydraulics 201 for Dam Safety (Miller, 2012) - ASDSO
5. Intro to the Application of 2D Hydraulic Modeling for Dam and Levee Safety (Hess and Israel-Devadason, 2016) - ASDSO
6. PMP and the History of HMRs (Tomlinson, 2012) - ASDSO
7. Rainfall and Dam Safety – From PMP to the 100-Year Storm (Kappel and Hultstrand, 2015) - ASDSO
8. HEC-RAS 2D Modeling (Hess & Miller, 2017) - ASDSO
9. Introduction to Physical Modeling of Spillways for Dams (Barfuss, 2012) - ASDSO
10. Introduction to Hydrologic Modeling Using Geospatial Information (Miller, Hess, and Krebs, 2015) - ASDSO
11. Introduction to Design of Labyrinth Spillways (Tullis, 2013) - ASDSO
12. Terminal Structures and Energy Dissipation for Outlet Works and Spillways (Frizell, 2013) - ASDSO
13. Intro to Addressing Inadequate Conveyance Capacity at Dams (Paul Schweiger, 2017) - ASDSO
14. Introduction to Earth Spillway Design and Evaluation (Temple, 2012) - ASDSO
15. Intro to Armoring Embankment Dams and Earth Cut Spillways with ACBs (Schweiger and Thornton, 2014) - ASDSO
16. Waterproofing Systems for Dams (Monserrate and Wilkes, 2015) - ASDSO
17. Rainfall and Dam Safety – From PMP to the 100-Year Storm (Kappel and Hulstrand, 2015) - ASDSO
18. Stepped Chute Spillway Design for Embankment Dams (Hunt, 2014) - ASDSO
19. Hydrologic Hazards – Estimating Probabilities of Extreme Floods (England, 2016) - ASDSO

20. Lawn Lake Dam: Pre-Failure Comprehensive Dam Safety Evaluation and Post Failure Impacts (McCormick & Baker 2019) - ASDSO
21. Intro to Cavitation in Chutes and Spillways (Falvey 2019) - ASDSO
22. WinDAM - Overtopping and Internal Erosion for Earthen Embankments (Visser & Fripp 2019) - ASDSO
23. Dam Overtopping Protection Systems – Part I (Hepler 2019) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

None created or identified to date.

GUIDELINES

<u>Hydrology</u>

1. Engineering Guidelines for the Evaluation of Hydropower Projects Chapter 2 - Selecting and Accommodating Inflow Design Floods for Dams (FERC, 2015)
2. Engineering Guidelines for the Evaluation of Hydropower Projects Chapter 8 - Determination of the Probable Maximum Flood (FERC, 2001)
3. Federal Guidelines for Dam Safety: Hazard Potential Classification Systems for Dams [FEMA 333] (FEMA, 2004)
4. Federal Guidelines for Dam Safety [FEMA 93] (FEMA, 2004)
5. Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams [FEMA 94] (FEMA, 2013)
6. Summary of Existing Guidelines for Hydrologic Safety of Dams [FEMA P-919] (FEMA, 2012)
7. Engineering and Design: Safety of Dams – Policy and Procedure [ER 1110-2-1156] (USACE, 2014)
8. Hydrologic Engineering Requirements for Reservoirs [EM 1110-2-1420] (USACE, 1997)
9. Flood-Runoff Analysis [EM 1110-2-1417] (USACE, 1994)
10. Hydrologic Analysis of Interior Areas [EM 1110-2-1413] (USACE, 1987)
11. Hydrologic Frequency Analysis [EM 1110-2-1415] (USACE, 1993)
12. Runoff from Snowmelt [EM 1110-2-1406] (USACE, 1998)
13. Flood Hydrology Manual (USBR; Cudworth, 1989)
14. Design Standards No.14: Appurtenant Structures for Dams (Spillway and Outlet Works)
Chapter 2: Hydrologic Considerations (USBR, 2013)
15. National Engineering Handbook, Part 630 – Hydrology [H.210.NEH.630] (NRCS, Various Years)

<u>Hydraulics</u>

1. Silver Lake Dam: Root Cause Report on the May 14, 2003 Operation of the Fuse Plug Spillway and Subsequent Channel Erosion Resulting in the Uncontrolled Release of Silver Lake (FERC, 2003) Report
2. Outlet Works Energy Dissipators: Best Practices for Design, Construction, Problem Identification and Evaluation, Inspection, Maintenance, Renovation, and Repair [P 679] (FEMA, 2010)
3. Overtopping Protection for Dams [P-1015] (FEMA – 2014)
4. ACER Technical Memorandum No.10 - Guidelines for Using Fuse Plug Embankments in Auxiliary Spillways (USACE, 1987)
5. Hydraulic Design of Flood Control Channels [EM 1110-2-1601] (USACE – 1994)

6. Hydraulic Design of Reservoir Outlet Works [EM 1110-2-1602] (USACE, 1980)
7. Hydraulic Design of Spillways [EM 1110-2-1603] (USACE, 1992)
8. Hydrologic Engineering Requirements for Reservoirs [EM 1110-2-1420] (USACE, 1997)
9. River Hydraulics [EM 1110-2-1416] (USACE – 1993)
10. Stability Design of Grass-Lined Open Channels [Agriculture Handbook No. 667] (USBR – 1987)
11. Design Standards No.14: Appurtenant Structures for Dams - Spillway and Outlet Works, Chapter 2: Hydrologic Considerations (USBR, 2013)
12. Design Note No. 6 - Riprap Lined Plunge Pool for Cantilever Outlet (USBR, 1986)
13. Design Note No. 8 - Entrance Head Losses in Drop Inlet Spillways (USBR, 1969)
14. Design of Small Dams (USBR, 1987)
15. National Engineering Handbook, Section 5: Hydraulics (NRCS)
16. Minimizing Embankment Damage During Overtopping Flow [FHWA-RD-88-181] (Federal Highway Administration, 1988)
17. Design of Riprap Revetment, Hydraulic Engineering Circular No. 11 [IP-89-016] (Federal Highway Administration, 1989)
18. A Guide for Design and Layout of Vegetable Wave Protection for Earth Dam Embankments, Technical Release No. 56 [TR-210-56] (NRCS, 2014)
19. Riprap for Slope Protection Against Wave Action, Technical Release No. 69 [TR-210-69] (Soil Conservation Service; NRCS, 1983)
20. Hydraulics of Broad-Crested Spillways, Technical Release No.39 [TR-210-39] (Soil Conservation Service; NRCS, 1968)
21. Criteria for the Hydraulic Design of Impact Basins Associated with Full Flow in Pipe Conduits, Technical Release No. 49 [TR-210-49] (Soil Conservation Service; NRCS,1971)

INSPECTION

TOPICS

1. Inspection and Assessment of Dams
2. Construction Inspections for Dams and Ancillary Structure
3. Visual Inspections: Woody Vegetation/Wildlife Penetrations on Earthen Dams
4. Review of Consultant Inspection Reports and Analyses

CLASSROOM COURSES

1. Plans and Specifications Review and Construction Inspections for Dams, Levees and Ancillary Structures - ASDSO
2. Inspection and Assessment of Dams -- ASDSO
3. SEED – Reclamation only
4. Operator Training – FERC, Reclamation, Corps

WEBINARS

1. Understanding and Managing Plant & Animal Intrusions in Embankment Dams and Levees (Zamensky, 2015) - ASDSO
2. Quality Assurance & Field Inspection for Dam Construction Projects (Freeland, 2014) - ASDSO
3. Intro to Inspecting Dams for Owners and Operators (Schweiger 2013) - ASDSO
4. Dam Construction Quality Control (Bass 2015) - ASDSO
5. Drone Technology Integrated into Dam Safety Inspections and Evaluations (Halligan and Crookston 2018) - ASDSO
6. Lawn Lake Dam: Pre-Failure Comprehensive Dam Safety Evaluation and Post Failure Impacts (McCormick & Baker 2019) - ASDSO
7. Intro to Post-Tensioned Anchors for Dams (Bruce 2019) - ASDSO
8. Lessons Learned Regarding Seismic Deformation Analyses of Embankment Dams from Re-Evaluation of the Upper and Lower San Fernando Dams Performance Case Histories (Seed & Chowdhury 2019) - ASDSO
9. Dam Overtopping Protection Systems – Part I (Hepler 2019) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

None created or identified to date.

GUIDELINES

1. Engineering Guidelines for the Evaluation of Hydropower Projects: Chapter 7 - Construction Quality Control Inspection Program (FERC, 1993)
2. Impacts of Animals on Earthen Dams [FEMA 473] (FEMA, 2005)
3. Impacts of Plants on Earthen Dams [FEMA 534] (FEMA, 2005)
4. Construction Control for Earth and Rock-Fill Dams [EM 1110-2-1911] (USACE, 1995)
5. Safety of Dams - Policy and Procedure [ER 1110-2-1156] (USACE, 2014)
6. Safety Evaluation of Existing Dams: A Manual for the Safety Evaluation of Embankment and Concrete Dams (USBR, 2000)

7. Design of Small Dams (USBR, 1987)
8. Low Hazard Dams Standing Operating Procedures (US FWS, 2008)
9. Operations and Maintenance Alternatives for Removing Trees from Dams (Soil Conservation Service; NRCS, 1981)
10. American Society for Testing and Materials Book of Standards, Section 4 – Construction

    Cement: Lime: Gypsum [Volume 04.01]

    Concrete and Aggregates [Volume 04.02]
    Road and Paving Materials; Vehicle–Pavement Systems [Volume 04.03]

    Chemical–Resistant Nonmetallic Materials; Vitrified Clay Pipe; Concrete Pipe; Fiber-Reinforced Cement Products; Mortars and Grouts; Masonry; Precast Concrete [Volume 04.05]
    Soil and Rock (I): D420 – D5876 [Volume 04.08]

    Soil and Rock (II): D5878 – latest [Volume 04.09]
11. American Society for Testing and Materials Book of Standards, Section 8 – Plastics, Plastic Piping Systems [Volume 08.04] (ASTM)

OPERATION AND MAINTENANCE

TOPICS

1. Best Practices in Operation and Maintenance
2. O&M for PL-566 Sponsors
3. Continuity in Operations During Emergencies

CLASSROOM COURSES

1. Dam Owner Workshop: Operation and Maintenance - ASDSO

WEBINARS

1. Development of Operations and Maintenance Manuals for Dams (Jamieson, 2014) - ASDSO
2. Understanding and Managing Plant & Animal Intrusions in Embankment Dams and Levees (Zamensky, 2015) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

None created or identified to date.

GUIDELINES

1. Federal Guidelines for Dam Safety [FEMA 93] (FEMA, 2004)
2. Dam Safety: An Owner's Guidance Manual [FEMA 145] (FEMA, 1987)
3. Pocket Safety Guide for Dams and Impoundments (FEMA, 2016)
4. Recommendations for Operation, Maintenance and Rehabilitation [ICOLD Bulletin 169] (ICOLD, 2017)
5. Dam Safety Management: Operational Phase of The Dam Life Cycle [ICOLD Bulletin 154] (ICOLD, 2017)
6. Impacts of Animals on Earthen Dams [FEMA 473] (FEMA, 2005)
7. Impacts of Plants on Earthen Dams [FEMA 534] (FEMA, 2005)
8. Safety of Dams - Policy and Procedure [ER 1110-2-1156] (USACE, 2014)
9. Safety Evaluation of Existing Dams: A Manual for the Safety Evaluation of Embankment and Concrete Dams (USBR, 2000)
10. Low Hazard Dams Standing Operating Procedures (US FWS, 2008)
11. Operations and Maintenance Alternatives for Removing Trees from Dams (Soil Conservation Service; NRCS, 1981)
12. Conduits through Embankment Dams [FEMA 484] (FEMA, 2005)
13. Design of Small Dams (USBR, 1987)
14. Training Aids for Dam Safety (TADS) (FEMA, 1988)

RISK ANALYSIS AND RISK-INFORMED DECISIONMAKING

TOPICS

1. Best Practices in Dam Safety Risk Assessment and Risk Analysis
2. DAMRAE (USACE)
3. Periodic Assessment Training
4. Risk Management for a Portfolio of Dams
5. Flood Damage Assessment
6. Communicating Risk

CLASSROOM COURSES

None created to date.

WEBINARS

1. Risk Assessment Basics for an Individual Dam (David Bowles, 2011) - ASDSO
2. Risk Management for a Portfolio of Dams (David Bowles, 2011) - ASDSO
3. Tolerable Risk Guidelines for Dams: How Safe is Safe Enough? (Bowles, 2013) - ASDSO
4. Loss of Life Consequence Assessment for Dam Failure Scenarios (Graham, 2013) - ASDSO
5. Intro to Potential Failure Modes Analysis (Boyer, 2014) - ASDSO
6. Applications of PFMA in Dam Safety (Boyer, 2014) - ASDSO
7. Event Tree Principles and Applications for Dam Safety Risk Analysis (Bowles, 2015) - ASDSO
8. Human Factors in Dam Failure and Safety (Alvi, 2015) - ASDSO
9. Introduction to Public Safety Risk Evaluation and Treatment for Dams and Levees (Cattanach, 2015) - ASDSO
10. Risk Assessment for Levee Projects (Shewbridge 2017) - ASDSO
11. Hydrologic Hazards – Estimating Probabilities of Extreme Floods (England, 2016) - ASDSO
12. How to Conduct a Successful PFMA (Boyer 2018) - ASDSO
13. Risk Communication for Dam Safety (Mullen and Wilson 2018) - ASDSO
14. Internal Erosion – Applying Erosion Mechanics From ICOLD Bulletin 164 In Internal Erosion Failure Mode Analyses (Bridle & France 2019) - ASDSO
15. Lawn Lake Dam: Pre-Failure Comprehensive Dam Safety Evaluation and Post Failure Impacts (McCormick & Baker 2019) - ASDSO
16. Intro to Post-Tensioned Anchors for Dams (Bruce 2019) - ASDSO
17. Lessons Learned Regarding Seismic Deformation Analyses of Embankment Dams from Re-Evaluation of the Upper and Lower San Fernando Dams Performance Case Histories (Seed & Chowdhury 2019) - ASDSO
18. WinDAM - Overtopping and Internal Erosion for Earthen Embankments (Visser & Fripp 2019) - ASDSO
19. Dam Overtopping Protection Systems – Part I (Hepler 2019) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

None created or identified to date.

GUIDELINES

1. Federal Guidelines for Dam Safety Risk Management [FEMA P-1025] (FEMA, 2015)

2. Risk Prioritization Tool for Dams (FEMA, 2008)

3. Dam Safety: An Owner's Guidance Manual [FEMA 145] (FEMA – 1987)

4. Dam Safety Assurance Program [EP 1110-2-1155] (USACE – 1997)

5. Dam Safety Preparedness [EP 1110-2-13] (USACE, 1996)

6. Reliability Analysis and Risk Assessment for Seepage and Slope Stability Failure Modes for Embankment Dams [ETL 1110-2-561] (USACE, 2006)

7. REMR Management Systems - Flood Control Structures: Condition Rating Procedures for Earth and Rockfill Embankment Dams (USACE, 1999)

8. Safety of Dam – Policy and Procedure [ER 1110-2-1156] (USACE, 2014)

9. A Procedure for Estimating Loss of Life Due to Dam Failure [DSO-99-06] (Bureau of Reclamation, 1999)

10. Best Practices in Dam Safety Risk Analysis (USBR, 2015)

11. INTERM - Dam Safety Public Protection Guidelines: A Risk Framework to Support Dam Safety Decision-Making (USBR, 2011)

12. ACER Technical Memorandum No. 7 - Guidelines to Decision Analysis (USBR, 1986)

13. INTERIM - Rationale Used to Develop Reclamation's Dam Safety Public Protection Guidelines (USBR, 2011)

SEISMIC

TOPICS

1. Earthquake Engineering – Advanced
2. Dynamic Seismic Analysis

CLASSROOM COURSES

None created to date.

WEBINARS

1. Earthquake Hazards, Ground Motions and Dynamic Response (Mejia and Fraser, 2014) - ASDSO
2. Seismic Evaluation of Earth Dams (Mejia and Armstrong, 2015) – ASDSO
3. Intro to Post-Tensioned Anchors for Dams (Bruce 2019) - ASDSO
4. Lessons Learned Regarding Seismic Deformation Analyses of Embankment Dams from Re-Evaluation of the Upper and Lower San Fernando Dams Performance Case Histories (Seed & Chowdhury 2019) - ASDSO
5. Explosive Phenomenology and Blasting Near Dams (Hossley & Rickman 2019) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

None created or identified to date.

GUIDELINES

1. Engineering Guidelines for the Evaluation of Hydropower Projects Chapter 13 - Evaluation of Earthquake Ground Motions (FERC, 2018)
2. Federal Guidelines for Earthquake Analyses and Design of Dams [FEMA 65] (FEMA, 2005)
3. Earthquake Design and Evaluation of Concrete Hydraulic Structures [EM 1110-2-6053] (USACE, 2007)
4. Evaluation and Comparison of Stability Analysis and Uplift Criteria for Concrete Gravity Dams by Three Federal Agencies [ERCE/ ITL TR-00-1] (USACE, 2000)
5. Rationalizing the Seismic Coefficient Method [GL-84 13] (USACE, 1984) Paper / Report
6. Seismic Design Provisions for Roller Compacted Concrete Dams [EP 1110-2-12] (USACE, 1995)
7. Design Standards No.13 Embankment Dams, Chapter 13: Seismic Analysis and Design (USBR, 2015)
8. Earth Dams and Reservoirs [TR-60] (NRCS, 2005)
9. Inspection of Dams Following Earthquake - Guidelines [ICOLD Bulletin 166] (ICOLD, 2016)
10. Federal Guidelines for Dam Safety [FEMA 93] (FEMA, 2004)

SITE SECURITY

TOPIC

1. Best Practices in Security Management for Dams
2. Asset Identification
3. Vulnerability Assessment
4. Risk Mitigation
5. Cyber Security
6. Crisis Management

CLASSROOM COURSES

1. Security of Dams – DHS Office of Infrastructure Protection

WEBINARS

None created.

SELF-PACED/ON-LINE SHORT COURSES

1. Dams Sector: Crisis Management (IS-870)
2. Dams Sector: Security Awareness (IS-871)
3. Dam Sector: Protective Measures (IS-872)

GUIDELINES

1. DHS Crisis Management Handbook: A Guide for Owners and Operators (DHS Dams Sector, 2015)
2. Active and Passive Vehicle Barriers (DHS Dams Sector, 2010)
3. Personnel Screening Guide for Owners and Operators (DHS Dams Sector, 2017)
4. Roadmap to Secure Control Systems (DHS Dams Sector, 2015)
5. Physical Security Measures for Levees Fact Sheet (DHS Dams Sector, 2016)
6. Emergency Preparedness Guidelines for Levees: A Guide for Owners and Operators (DHS Dams Sector, 2012)
7. Waterside Barriers Guide (DHS Dams Section, 2017)
8. Estimating Loss-of-Life for Dam Failure Scenarios (DHS Dams Sector, 2011)
9. Estimating Economic Consequences for Dam Failure Scenarios (DHS Dams Sector, 2011)
10. Dams Sector Suspicious Activity Reporting Fact Sheet (DHS Dams Sector, 2016)
11. Suspicious Activity Report Flyer (DHS Dams Sector, 2011)
12. Dams Sector Cybersecurity Program Guidance (DHS Dams Sector, 2016)
13. Dams Sector Cybersecurity Capability Maturity Model: (C2M2) (DHS Dams Sector, 2016)
14. Dams Sector Security Guidelines (DHS Dams Sector, 2015)
15. Dams Sector Security Awareness Guide (DHS Dams Sector, 2007)

STRUCTURAL

TOPICS

1. Fundamentals of Reinforced Concrete Design for Hydraulic Structures (basic)
2. Conduit, Valves and Gates
3. RCC Design and Construction– Basic and Advanced
4. Filter Drains
5. Design Concepts: Welding, Concrete Mix, Concrete Pipes, Reinforced Concrete
6. Finite Element Analysis
7. Analysis of Concrete Dams
8. Inspection of Concrete Structures
9. Quality Control and Testing
10. Evaluation of Buried Pipes
11. Design and Rehab of Outlet Works
12. Stability Analysis for Dams and Appurtenant Structures
13. Thermal Analysis for Mass Concrete Structures
14. Repair of Dam Appurtenances including Concrete Structures, Conduits, Valves, Gates, Etc.
15. Use of Post-Tensioned Anchors and Other Anchor Methods
16. Rubber Dams
17. Fuse Plugs
18. Timber
19. Design and Evaluation of Towers, Outlets, Tunnels and Bridges

CLASSROOM COURSES

1. Fundamentals of Reinforced Concrete Design for Hydraulic Structures - ASDSO
2. Conduits, Gates and Valves - ASDSO

WEBINARS

1. Roller Compacted Concrete – Design and Construction of Water Control Structures (Bass, 2011) - ASDSO
2. RCC Applications in Dam Engineering - What We Have Learned and What's New (Hansen, 2013) - ASDSO
3. Introduction to Concrete Gravity Dams (Kline, 2012) - ASDSO
4. Rehabilitation of Concrete Dams (Kline, 2014) - ASDSO
5. Stability Evaluations for Concrete Dams (Kline and Lund, 2013) - ASDSO
6. Analysis of Concrete Arch Dams (Lund 2018) - ASDSO
7. Filter Design History and a One-Step Process (McCook and James Talbot, 2011) - ASDSO
8. Terminal Structures and Energy Dissipation for Outlet Works and Spillways (Frizell, 2013) - ASDSO
9. 3D Weirs for Dam Safety (Paxson and Crookston, 2016) - ASDSO
10. Design of Siphon Systems (Kline 2017) - ASDSO
11. Intro to Addressing Inadequate Conveyance Capacity at Dams (Schweiger, 2017) - ASDSO
12. Pitfalls in Quality Control Processes for Compacted Earthfill (McCook, 2010) - ASDSO
13. Foundation Preparation during Dam Construction (France, 2014) - ASDSO
14. Stability Evaluations for Concrete Dams (Kline and Lund, 2013) - ASDSO
15. Strength Selection For Static Slope Stability Analysis (France and Winckler, 2016) - ASDSO
16. Seepage Rehabilitation for Embankment Dams (France and Williams, 2015) - ASDSO
17. Dam Construction Quality Control – Do's, Don'ts, and Lessons Learned (Bass, 2015) - ASDSO
18. Rehabilitation of Concrete Dams (Robert Kline, 2014) - ASDSO
19. Quality Assurance & Field Inspection for Dam Construction Projects (Freeland, 2014) - ASDSO
20. Dam Construction Quality Control – Do's, Don'ts, and Lessons Learned (Bass, 2015) - ASDSO

21. RCC-Design and Construction of Water Control Structures (Randy Bass, 2011) - ASDSO
22. RCC Applications in Dam Engineering – What We have Learned and What's New (Kenneth Hansen, 2013)- ASDSO
23. Intro to Post-Tensioned Anchors for Dams (Bruce 2019) - ASDSO
24. Best Management Practices for Waterstop Selection, Installation, and Inspection (Kudritz & Afec 2019) - ASDSO
25. Dam Overtopping Protection Systems – Part I (Hepler 2019) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

None created or identified to date.

GUIDELINES

Design and Analysis of Spillway Gates

1. Conduits through Embankment Dams [FEMA 484] (FEMA, 2005)
2. Engineering and Design: Evaluation and Repair of Concrete Structures [EM 1110-2-2002] (USACE, 1995)
3. Engineering and Design: Design of Spillway Tainter Gates [EM 1110-2-2702] (USACE, 2000)
4. Repair of Dam Intake Structures and Conduits: Case Histories [TR-REMR-CS-16] (USACE, 1988)
5. Engineering and Design: Standard Practice for Concrete for Civil Works Structures [EM 1110-2-2000] (USACE, 1994)
6. Engineering and Design: Structural Design and Evaluation of Outlet Works [EM 1110-2-2400] (USAC, 2003)
7. Design of Small Dams (USBR, 1987)

Use of Post-Tensioned and Other Anchor Methods for Dams

1. Post-Tensioning Tendon Installation and Grouting Manual [FHWA-NHI-13-026] (US Department of Transportation Federal Highway Administration, 2013)

Repair of Dam Appurtenance Including Concrete Structure, Conduits, Gates Valves Etc.

1. Conduits through Embankment Dams [FEMA 484] (FEMA, 2005)
2. Engineering Guidelines for the Evaluation of Hydropower Projects: Chapter 3 - Gravity Dams (FERC, 2016)
3. Engineering and Design: Evaluation and Repair of Concrete Structures [EM 1110-2-2002] (USACE, 1995)
4. Engineering and Design: Standard Practice for Concrete for Civil Works Structures [EM 1110-2-2000] (USACE, 1994)
5. Engineering and Design: Arch Dam Design [EM 1110-2-2201] (USACE, 1994)
6. Engineering and Design: Gravity Dam Design [EM 1110-2-2200] (USACE, 1995)
7. Repair of Dam Intake Structures and Conduits: Case Histories [TR-REMR-CS-16] (USACE, 1988)
8. Engineering and Design: Standard Practice for Concrete for Civil Works Structures [EM 1110-2-2000] (USACE, 1994)
9. Engineering and Design: Structural Design and Evaluation of Outlet Works [EM 1110-2-2400] (USAC, 2003)
10. Design of Small Dams (USBR, 1987)
11. Design of Arch Dams (USBR, 1995)
12. Design of Gravity Dams (USBR, 1995)

Thermal Analysis for Mass Concrete Structures

1. Engineering and Design: Thermal Studies for Mass Concrete Structures [EM 1110-2-542] (USACE, 1997)

Stability Analyses for Dam and Appurtenant Structures

1. Engineering Guidelines for the Evaluation of Hydropower Projects: Chapter 3 - Gravity Dams (FERC, 2016)
2. Engineering and Design: Arch Dam Design [EM 1110-2-2201] (USACE, 1994)
3. Engineering and Design: Gravity Dam Design [EM 1110-2-2200] (USACE, 1995)
4. Engineering and Design: Stability Analysis of Concrete Structures [EM 1110-2-2100] (USACE, 2005)
5. Design of Small Dams (USBR, 1987)
6. Design of Arch Dams (USBR, 1995)
7. Design of Gravity Dams (USBR, 1995)

Design and Rehabilitation of Outlet Works

1. Selecting Analytic Tools for Concrete Dams Address Key Events Along Potential Failure Mode Paths [FEMA P-1016] (FEMA, 2014)
2. Conduits through Embankment Dams [FEMA 484] (FEMA, 2005)
3. Plastic Pipe Used in Embankment Dams [FEMA P675] (FEMA, 2007)
4. Repair of Dam Intake Structures and Conduits: Case Histories [TR-REMR-CS-16] (USACE, 1988)
5. Engineering and Design: Structural Design and Evaluation of Outlet Works [EM 1110-2-2400] (USACE, 2003)
6. The Structural Design of Underground Conduits [Technical Release No. 5] (Soil Conservation Service; NRCS, 1958)
7. Single Cell Rectangular Conduits - Criteria and Procedures for Structural Design [Technical Release No. 42] (Soil Conservation Service; NRCS, 1969)
8. Twin Cell Rectangular Conduits - Criteria and Procedures for Structural Design [Technical Release No. 45] (Soil Conservation Service; NRCS, 1970)
9. Structural Design of SAF Stilling Basins [Technical Release No. 54] (NRCS, 1974)
10. National Engineering Handbook – Part 636 Structural Engineering Chapter 52 Structural Design of Flexible Conduits (NRCS, 2005)

Evaluation for Concrete Structures

1. Guide to Concrete Repair (USBR, 2006)

Fundamentals of Conventional Concrete Design and Construction for Hydraulic Structures

1. Engineering and Design: Stability Analysis of Concrete Structures [EM 1110-2-2100] (USACE, 2005)
2. Engineering and Design: Strength Design for Reinforced Concrete Hydraulic Structures [EM 1110-2-2104] (USACE, 2003)
3. National Engineering Handbook – Part 636 Structural Engineering Chapter 52 Structural Design of Flexible Conduits (NRCS, 2005)

SURVEILLANCE AND MONITORING PERFORMANCE

CLASSROOM COURSES

None created or identified to date.

WEBINARS

1. Using Instrumentation for Dam Safety Monitoring (Myers, 2013) - ASDSO
2. Stability Evaluations for Concrete Dams (Kline and Lund, 2013) - ASDSO
3. Structural Condition Assessment of Dam Facilities with Non-Destructive Evaluation Methods (Olson, 2012) - ASDSO
4. Intro to Tailings Dam and Coal Ash Impoundment Design, Construction and Monitoring: Current Practice (Davidson and Winckler, 2016) - ASDSO
5. Evaluation and Maintenance of Piezometers, Relief Wells and Drains in Dams and Levees (Easton & Springer 2018) - ASDSO
6. Lawn Lake Dam: Pre-Failure Comprehensive Dam Safety Evaluation and Post Failure Impacts (McCormick & Baker 2019) - ASDSO
7. Intro to Post-Tensioned Anchors for Dams (Bruce 2019) - ASDSO
8. Relearning How to Look at Piezometric Data for Seepage Evaluation (Olson 2019) - ASDSO
9. Explosive Phenomenology and Blasting Near Dams (Hossley & Rickman 2019) - ASDSO

SELF-PACED/ON-LINE SHORT COURSES

None created or identified to date.

GUIDELINES

1. Engineering Guidelines for the Evaluation of Hydropower Projects Chapter 14 - Dam Safety Performance Monitoring Program (FERC, 2017)
2. Engineering Guidelines for the Evaluation of Hydropower Projects Chapter 9 - Instrumentation and Monitoring (FERC, 2015)
3. Dam Safety: An Owner's Guidance Manual [FEMA 145] (FEMA, 1987)
4. Safety of Dams – Policy and Procedure [ER 1110-2-1156] (USACE, 2014)
5. Engineering and Design: Instrumentation for Concrete Structures [EM 1110-2-4300] (USACE, 1987)
6. Engineering and Design: Instrumentation of Embankment Dams and Levees [EM 1110-2-1908] (USACE, 1995)
7. Concrete Dam Instrumentation Manual (USBR, 1987)
8. Design Standards No. 13: Embankment Dam Chapter 11: Instrumentation and Monitoring (USBR, 2014)
9. Safety Evaluation of Existing Dams: A Manual for the Safety Evaluation of Embankment and Concrete Dams (USBR, 2000)
10. Low Hazard Dams Standing Operating Procedures (US FWS, 2008)

MISCELLANEOUS

TOPICS

1. Reservoir Sedimentation

CLASSROOM COURSES

None created or identified to date.

WEBINARS

None created or identified to date.

SELF-PACED COURSES

None created or identified to date.